D6.3 Evaluation of user experiences and lessons learnt

Christensen, Toke Haunstrup; Knudsen, Henrik N.; Yara, Agustina; Serrano, María Luisa; Ní Fhlaithearta, Laoise; Correa, Dayanne Peretti

Publication date:
2020

Document Version
Publisher's PDF, also known as Version of record

RESPOND
DEMAND RESPONSE FOR ALL

Integrated Demand REsponse SOlution Towards Energy POsitive NeighbourhooDs

WP6 Validation and replication of project results

T6.3 Qualitative evaluation of user experiences and recommendations

D6.3 Evaluation of user experiences and lessons learnt

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768619

PROJECT ACRONYM	RESPOND
DOCUMENT	**D6.3 Evaluation of user experiences and recommendations**
TYPE (DISTRIBUTION LEVEL)	■ Public ☐ Confidential ☐ Restricted
DELIVERY DUE DATE	31.07.2020
DATE OF DELIVERY	30.09.2020
STATUS AND VERSION	v1.0 Final
DELIVERABLE RESPONSIBLE	AAU
AUTHOR (S)	Toke Haunstrup Christensen & Henrik N. Knudsen (AAU), Agustina Yara and María Luisa Serrano (TEK), Laoise Ní Fhlaithearta (ARAN) and Dayanne Peretti Correa (NUIG)
OFFICIAL REVIEWER(S)	FEN

DOCUMENT HISTORY

	ISSUE DATE	CONTENT AND CHANGES
0.1	07.07.2020	Table of contents (outline)
0.2	10.09.2020	Table of contents (revised)
0.3	14.09.2020	Contribution to Ch. 2 received from FEN
0.4	21.09.2020	Review comments from FEN and ARAN
0.5	23.09.2020	Contribution to Ch. 2 received from NUIG
0.6	28.09.2020	Review by FEN and comments from NUIG
1.0	30.09.2020	Final version

EXECUTIVE SUMMARY

This deliverable is part of the project *Integrated Demand REsponse SOlution Towards Energy POsitive NeighbourhooDs* (RESPOND) and it reports the activities and findings from Task 6.3 *Evaluation of user experiences and lessons learnt*. The main goal of Task 6.3 was to report on the overall user engagement and satisfaction during the RESPOND demonstration activities (e.g. utilising the RESPOND personal assistant application for smartphones). The evaluation of user experiences is based on qualitative interviews and a questionnaire survey and has in particular focused on providing a better understanding of how the RESPOND solutions have been used and experienced by the participating households, incl. how the solutions fit in with the everyday practices of the households. The aim is that the findings of this deliverable should inspire the work of technical designers and others involved to develop better future DR solutions for households.

Several DR and energy feedback solutions have been trialled at the three RESPOND pilot sites (Madrid, Aran Islands and Aarhus) during the winter, spring and summer of 2020. In total, seven different use cases have been trialled. Each use case includes a certain technical solution and/or DR scheme, which has been trialled at one or more pilot sites. It is the user experiences related to these use cases that are reported in this deliverable. A list of lessons learned for each of the use cases are made based on an analysis of the results.

The user engagement study has demonstrated that – despite some challenges related to the users' involvement and interaction with the RESPOND app and DR solutions – the pilot households at all three sites have been highly dedicated and engaged pilot participants.

On basis of the user engagement study of the RESPOND project, the following lessons learned can be identified for each of the seven use cases (UCs):

UC1 Mobile app providing energy data feedback to households (deployed at all sites):

- The design of mobile apps should take into consideration that in most cases only one person in a household (typically a male adult) uses the app – and that this person might not be the person who performs the household activities with the highest energy consumption (e.g. clothes washing).
- Age plays a role as older people in general tend to find it more difficult to download and use the app (even though this age group also includes a minority of very active app users). Mobile apps should be designed to be easy to use also by older people.
- It is important that mobile apps are intelligible (easy to navigate), fast (load pages quickly) and reliable (no errors or breakdowns).
- Many households find it interesting to compare their own energy consumption with that of their neighbours, and such comparisons can spur energy saving actions.

UC2 & UC6 Maximise auto-consumption from PV panels by sending mobile app notifications to households about optimal time to consume electricity (Aran & Aarhus):

- Individual ownership (as in UC2) of PV panels appears to result in a more active engagement in demand response actions than shared ownership as in social housing

associations (as in UC6). Thus, to engage tenants in such actions, it is important to allocate financial gains from time-shifting consumption to the individual tenants.

- App notifications with recommendations on demand response actions can be a helpful tool, especially as a reminder and learning tool for households that have not already established such DR practices.

UC4 Motivate households to peak-shave consumption during grid peaks by use of mobile app notifications (Aran):

- If app notifications on peak-shaving actions shall have an effect on households' electricity consumption, these must be combined with some kind of incentive, e.g. a financial incentive like high prices during peak hours or a bonus/premium for reducing power consumption.

UC5 Load-shifting district heating by central (remote) control of radiator thermostats (Aarhus):

- The DR concept of time shifting heating in the morning by central (remote) control of radiator thermostats showed to be a usable solution for peak shaving. This despite of occupants experiencing some negative impact on the perceived indoor thermal environment in the morning.
- Before introducing DR schemes with heating setback, it is recommended to establish conditions allowing occupants to adjust the temperature in their dwelling to their preference. This may require an increased heating capacity of the radiator system, better wall insulation and/or new low energy windows.
- Knowing the plan and intentions behind a DR scheme can make the occupants more acceptant to changes in their indoor temperatures during DR actions – especially if the positive implications for the local neighbourhood or wider society (e.g. the environment) is communicated to them.
- Saving money (financial incentives) is a motivational element for households to participate – though, and importantly, not the only motivational element.
- The heat DR scheme should be designed in a way that allow occupants to adjust the temperature level to their preference and allow for some freedom to adjust the setback scheme and accepted temperature variations according to their individual needs.
- Heat DR schemes based on control of individual thermostats (radiators) implies a high level of technical complexity, which makes the system vulnerable to technical problems. This needs to be considered and weighted against more simple and robust DR solutions based on e.g. central control.

UC7 Price-based DR for electricity consumption – combining "happy hours" with app notifications to households (Madrid):

- Static Time-of-Use schemes with a significant economic incentive (like "happy hours" of free of charge electricity) motivate households to time-shift consumption away from peak-hours.

- The duration of low-price periods should be – at minimum – two hours in order to make it possible for households to run appliances such as dishwashers, washing machines and tumble dryers, which are the appliances that are in general most often time-shifted.

UC8 Maximise exploitation of DHW RE resources by sending app notifications to households about when it is best to consume DHW (Madrid):

- There is a limited potential for making households time-shift their domestic hot water (DHW) consumption as a way to optimize the utilisation of local solar thermal energy production.

TABLE OF CONTENTS

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

DR	Demand Response
DSM	Demand-Side Management
ICT	Information and Communication Technologies
WiFi	Wireless Fidelity (radio wireless local area networking)

1. INTRODUCTION

This deliverable D6.3 *Evaluation of user experiences and lessons learnt* presents the work and findings of Task 6.3 *Qualitative evaluation of user experiences and recommendations*, which is part of WP6 *Validation and replication of project results* of the RESPOND project.

The main aim of Task 6.3 was to report on the overall user engagement and satisfaction during the RESPOND demonstration activities at pilot sites and in interaction with the RESPOND DR system itself (e.g. utilising the RESPOND personal assistant application for smartphones deployed in Task 5.4). Originally, it was planned to base the evaluation of a combination of focus groups at the pilot sites and a questionnaire survey. However, due to the current Covid-19 situation, it was not possible to carry out focus groups for health reasons. Instead of focus groups, we have done a series of qualitative interviews with occupants from the households from the pilot sites. The background for, and implications of, this shift from focus groups to qualitative interviews is described in more detail in the following section. In addition to the focus groups, we have also carried out a questionnaire survey for one of the use cases trialled at the Aarhus pilot site.

The user engagement assessment has in particular focused on providing a better understanding of how the RESPOND solutions have been used and experienced by the participating households, incl. how the solutions fit in with the everyday life and practices of the households. The latter gives qualitative insights on how the specific design of solutions work together with the "real-life user context" within the homes of the households. A better understanding of the dynamic interrelation between technical designs and user contexts provides important input for future work of technical designers and others on developing improved and more comprehensive DR solutions for households.

During the winter, spring and summer of 2020, a number of DR and energy feedback solutions have been trialled at the three sites in the RESPOND project (Madrid, Aran Islands and Aarhus). Previously in the project, eight different "use cases" were defined (see RESPOND deliverable D6.1 *RESPOND Validation methodology*). In each of these use cases, a certain technical solution and/or DR scheme was to be trialled at one or more sites. It is the user experiences related to these use cases that are reported in this deliverable. However, due to the Covid-19 situation, one of these use cases (UC3) was simulated instead of carried out in "real-life" (the use case was validated by using the Building Simulator and Option D of IPMVP (Simulations)). Therefore, use case UC3 is not reported in this deliverable, but further information about it can be found in RESPOND deliverable D6.5.

In the following chapter, we will introduce the methods applied for preparing the user engagement assessment (Ch. 2). This chapter also briefly presents the use cases that were studied at the three pilot sites. Then follows the analysis of the collected data from qualitative interviews and a questionnaire survey (Ch. 3). The main findings from this analysis are summarized in the concluding chapter, which also includes an overview of the most important "lessons learnt" (Ch. 4).

2. METHODS

This section introduces the methods applied for the evaluation of the user engagement in the RESPOND project. First, qualitative interviews, as a method, is briefly introduced (section 2.1). Then follows a more detailed presentation of the design of the RESPOND interviews carried out at the three pilot sites – including descriptions of the RESPOND use cases related to the site interviews (section 2.2), and an introduction to the questionnaire survey used in relation to UC5 in Aarhus (section 2.3). The chapter concludes with a brief description of how the qualitative interviews have been analysed in order to provide the final user engagement assessment.

2.1 INTRODUCTION OF QUALITATIVE INTERVIEWS AS A METHOD

It was originally planned to carry out two focus groups at each pilot site. Focus groups is a method that brings a small number of participants together to discuss a certain topic. It is an efficient method for providing a variety of perspectives on a specific topic, e.g. how the RESPOND solutions have been experienced by the participating households. However, due to the Covid-19 situation, it was not possible to carry out focus groups, as these requires physical presence of the participants as well as the focus group moderators. Instead, it was decided to carry out 5-10 qualitative interviews with individual occupants from households at each pilot site. Unlike focus groups, it is possible to carry out individual interviews by use of communication media such as Skype or regular telephone calls.

Qualitative interviewing is a well-established and often-used method within social sciences (Brinkmann & Kvale, 2015). Interviews can be performed in many different ways, but the semi-structured qualitative interview is the most common interview form, which is also the method used here. In semi-structured interviews, the interview is structured by an interview guide, which contains a list of topics and questions that has been prepared in advance. These topics and questions ensure that the interview is covering the research questions that have been identified as important. The interview guide also ensures consistency in focus across interviews, which makes it possible to compare across interviews and make more general conclusions. However, the interview guide is not a “straitjacket”, as it is allowed to rephrase questions in the interview situation (e.g. adapting the phrasing of questions to the specific context or what the interviewee has said earlier in the interview). It is also allowed to add new questions during the interview setting, e.g. in order to follow-up on new interesting perspectives or observations that might arise during the interview. This flexibility is why this type of interviewing is called *semi*-structured interviews, and this is also what makes semi-structured interviews different from questionnaires with fixed questions. In other words, qualitative interviews are placed in between the fixed questions of surveys and the openness of everyday conversations between people.

Change in methods will inevitably have an impact on the data produced and the final analysis and conclusions. In our case, it is likely that focus groups would have provided more diversity with regard to perspectives on how the participants experienced taking part in the RESPOND use cases. Also, focus groups would likely have provided a deeper insight into normative positions that can influence whether households will take part in such DR schemes. However, on the benefit site, individual interviews typically give a deeper insight into the everyday routines and everyday

life of the interviewed than in the case of focus groups. Therefore, it might be assumed that the shift in methods has resulted in a more nuanced understanding of how the RESPOND use cases and DR actions fit in with the everyday life and everyday practices of the household members.

The interviews in Aarhus and on Aran Islands were recorded in order to support the work with writing detailed summaries of the interviews. Recordings were only made upon prior informed consent by interviewees, and recordings were only used by the interviewers and were not and will not be shared with others. It was decided not to record the interviews in Madrid, as this was considered by the local pilot partner to be too sensitive to ask the interviewees about (due to a more critical attitude in Spain towards this form of recordings). Instead, the interviewer of the Madrid interviews made extensive notes during the interviews, which formed the basis for the written interview summaries.

2.2 THE DESIGN OF THE RESPOND INTERVIEWS

As the RESPOND project covers many different use cases (UC1 to UC8), and all use cases (except UC1) are only trialled at one pilot site, it is not possible to make one interview guide that can be used at all sites. Thus, the interview guides had to be tailored to the individual sites and relevant use cases.

In order to facilitate the process of preparing the interview guides for each site, the task leader (AAU) prepared a general guideline on how to do this (see Annex 1). In addition to general descriptions of how to prepare interview guides and perform qualitative interviews, the guideline also included an example of an interview guide prepared by AAU for the interviews to be performed with households who had participated in UC5 on time shifting heating in Aarhus. This was intended to be of inspiration to the other pilot partners for their work with preparing specific guidelines relevant for their interviews.

The guideline was distributed to the relevant pilot partners (FEN in Madrid and ARAN/NUIG on Aran Islands), who developed a draft of the interview guides to be used for their pilot site interviews. This draft was then commented by the task leader (AAU) in order to help with creating optimal guidelines for the interviews.

The preparation of the interview guides was carried out in the spring of 2020. The interviews were carried out during the summer – from May to August 2020. Further details about the use cases and the content of the interview guides for the individual pilot sites are presented in the next section.

With regard to choice of medium for the interviews (regular phone calls versus online media like Skype), it was up to the individual pilot partners to decide. The interviews in Madrid and on Aran Islands were carried out by phone, as this was estimated to be the most convenient medium to use by the interviewees. In Aarhus, most interviews were carried out by use of Skype calls. It was estimated that most of the interviewees would be familiar with Skype calls (which turned out to be correct), and by using Skype, it was possible to have both audio and visual connection, as well as record the interviews. Studies indicate that using video calls improve the interview settings as the visual connection between interviewer and interviewee supports the interaction and communication during the interview (e.g. makes it less formal than can be the case of phone interviews) (Deakin & Wakefield, 2013).

2.2.1 AARHUS (DENMARK)

USE CASES

Three use cases were trialled at the Aarhus pilot site. Here follows a brief description of the use cases.

UC1 – Mobile app providing energy data feedback to households

In parallel with the other two pilot sites, the Aarhus households were invited to install and use the RESPOND app. Log-on credentials were sent by AURA by email to all Aarhus households by the middle of April 2020. Hereafter, it was up to the households to download and install the app. Within the first weeks upon sending the log-on credentials, about half of the 20 Aarhus pilot households had downloaded and installed the app. To increase the share of users, another letter was sent both by email and delivered as a letter to the household by AURA in the beginning of June 2020. This letter encouraged (again) the households to install the app – and recommended those, who had already installed the app, to upgrade to the most recent version of the app, as a new version had been released after the first email was sent. By 11th of June 2020, 12 households had downloaded and logged on to the RESPOND app. By the beginning of August, a new version of the app was released (version 1.17), which now also included a chart that compared the share of local solar power in the electricity consumption of the individual household with the share of the neighbours (average) and of those neighbours with the highest share of PV power.

UC5 Load-shifting district heating by central (remote) control of radiator thermostats

The aim of this use case was to test how time-shifting of space heating is experienced by the occupants. For various reasons, district-heating suppliers may want to make it possible to time-shift some of the heat delivered to homes. The most important reason for this is that suppliers in various areas are experiencing problems with delivering enough heat (e.g. if the building stock has been expanded with new housing), especially in the morning when the demand for heat peaks due to many people taking a shower more or less simultaneously. This means that suppliers either have to invest in upgrading the district heating system (e.g. pipes in the ground), which might be costly and make the heat more expensive for customers, or - alternatively - find ways to time-shift some of the consumption away from the peak hours. UC5 aim at testing the latter solution by installing modern thermostats in homes that can be controlled remotely. Hereby making it possible for the company to switch off the heat shortly during the few hours with peak consumption in the morning. Of course, only with the prior acceptance from the tenants. For the dwellings in the Danish pilot site in ALBOA, model calculations indicate that this will only result in a limited drop of about 1°C per hour during the few hours when the heating is switched off.

Prior to the UC5 trial, new digital thermostats and gateways were installed and connected. This was done in the autumn of 2019 and involved a lot of challenges and work related to making the thermostats and gateways work properly. The occupants then had around two and a half months (from around mid-November to the start of the experiment in February) where they could get familiar with the new Danfoss ECO thermostats. They could adjust the thermostats to their own preference, similar to how they did before getting the new thermostats. During the UC5 trial, the

tenants could also adjust the temperature level in each room of a dwelling as they used to do it. As a result, the thermostats in each room of the dwelling would have a specific "preferred set-point" on the thermostats. This set point value was then read remotely by the RESPOND DR system, and was the starting point for the DR action, i.e. changing the set point to 16°C (which normally means switching off) the thermostats, and later returning the thermostats to the "preferred set-point" as it was before.

The new Danfoss ECO thermostats were controlled in the following way. To get started in a simple manner (without a fully functioning app, and without online communication with the occupants to "fine tune" when and how much the temperature in their specific dwelling was affected), it was decided to control all thermostats in all the dwellings following the same plan. An exception was the thermostats in the bathroom on first floor that was left as the occupants have adjusted them. This was to meet a desire for maximum thermal comfort in the bathroom, which was a wish expressed during the initial focus group interview (see RESPOND deliverable D3.3 *Findings and recommendations from focus groups on user context*), and for not increasing the risk for mold growth in the bathroom.

The reason for not just totally turning off (or adjusting to a very low set-point, e.g. 5°C) the thermostats is twofold. 1) To ensure that the temperature does not get "too low", i.e. outside what the occupants can accept from a thermal comfort point of view, and 2) to make sure the temperature in the dwelling does not get so low that it creates problems for the building due to condensation on walls and the accompanying risk of molds.

During the weekends, the thermostats were reset to the preferred set-points from Friday midnight to Sunday midnight.

Unfortunately, it turned out that around half of the DR actions did not succeed, see table 1 or Annex 2 for a large version of Table 1. To study the occupants' experiences during real DR actions, the data from unsuccessful DR actions therefore had to be excluded.

TABLE 1: SUCCESSFUL DR ACTIONS (GREEN), DR WITH ANOMALIES (ORANGE) AND UNSUCCESSFUL DR ACTIONS (RED)

Dwelling No.	Comments	Test week 1 3. February - 9. February	Test week 2 10. February - 16. February (holiday week)	Test week 3 17. February - 23. February	Test week 4 24. February - 1. March	Test week 5 2. March - 8. March	Test week 6 9. March - 15. March	Test week 7 16. March - 22. March	Test week 8 23. March - 29. March	Test week 9 30. March - 5. April	Test week 10 6. April - 12. April
DR action	Thermostat remotely controlled	No DR actions (baseline)		7 am: set-points lowered to 16°C 8 am: set-points back to "preferred set point"		4 am: set-point raised 1°C above "preferred set point" 6 am: set-points lowered to 16°C 9 am: set-points back to "preferred set point"		6 am: set-points lowered to 16°C 9 am: set-points back to "preferred set point"		No DR actions (baseline)	
Aarhus_01				0/5	0/5	2/5	4/5	4/5	5/5		
Aarhus_02	No device found			0/5	0/5	0/5	0/5	0/5	0/5		
Aarhus_03				5/5	5/5	5/5	5/5	4/5	5/5		
Aarhus_04				5/5	4/5	4/5	4/5	3/5	0/5		
Aarhus_05				5/5	3/5	5/5	3/5	4/5	5/5		
Aarhus_06				5/5	5/5	4/5	4/5	0/5	0/5		
Aarhus_08				5/5	4/5	4/5	5/5	0/5	0/5		
Aarhus_09				5/5	5/5	5/5	5/5	5/5	4/5		
Aarhus_11	No quantification			?	?	?	?	?	?		
Aarhus_15	No quantification			Maybe DR action	Maybe DR action	Maybe DR action	Maybe DR action	Maybe DR action	Maybe DR action		
DR Scheme		Nothing	Nothing	1h DR	1h DR	3h DR with preheating	3h DR with preheating	3h DR	3h DR	Nothing	Nothing

Experimental plan

Based on the specific needs for time-shift of space heating away from peak hour in the morning, defined by the district heat company AffaldVarme Aarhus, a series of three different DR actions were planned. The new thermostats, that could be remotely controlled, were installed in ten of the participating dwellings (Aarhus: 01, 02, 03, 04, 05, 06, 08, 09, 11, and 15). The idea was to switch

off the heat by lowering the temperature set-point of the thermostats to 16°C, for one hour from 7 am to 8 am or 3 hours from 6 am to 9 am.

Three different scenarios of load-shifting of district heating were tested starting with the smallest intervention and ending with the largest intervention (see details below). Based on the initial focus group interviews (see RESPOND deliverable D3.3 *Findings and recommendations from focus groups on user context*) it was decided to include a scenario to try to maintain the temperature within a comfortable range, by preheating prior to switching off the heat. This was done by increasing the set point of the thermostats with 1°C for 2 hours, prior to switching off the heat for 3 hours. From an energy point of view, it may be preferred not to preheat. Therefore, an experiment without preheating was included as the last scenario. The experimental plan during the ten test weeks were as follows:

- Test week 1-2 (03-02-2020 to 16-02-2020): No DR actions. Baseline period 1.
- Test week 3-4 (17-02-2020 to 01-03-2020): One hour of temperature setback (temperature setpoint lowered to 16°C between 7 and 8 am).
- Test week 5-6 (02-03-2020 to 15-03-2020): Two hours of pre-heating (set-point temperature raised +1°C between 4 and 6 am); three hours temperature setback (temperature setpoint lowered to 16°C between 6 and 9 am).
- Test week 7-8 (16-03-2020 to 29-03-2020): Three hours of temperature setback (temperature setpoint lowered to 16°C between 6 and 9 am).
- Test week 9-10 (30-03-2020 to 12-04-2020): No DR actions. Baseline period 2.

UC6 Maximise auto-consumption from grid-connected PV panels

Beginning from 25th of May 2020, app notifications were issued to the Aarhus pilot households on a daily basis in order to maximise auto-consumption of the power from the PV panels of the housing association. The notifications informed the residents about when it would be best to consume electricity, i.e. in which hours the production of the social housing association's own PV panels would peak according to predictions based on local weather data. Until the 23rd of July, the notifications in general recommended consumption during most of the day hours (e.g. from 9 am to 6 pm), which was due to the fact that the PV panels of the housing association generates more electricity than is locally consumed during many hours of the day in the summer period. However, as this does not represent a more typical use case during other seasons (in particular spring and autumn), the protocol was changed so from the 23rd of July and onwards, the recommendation was limited to the two hours of the day with maximum PV power production (which can shift between morning, midday and afternoon from day to day, depending on the weather predictions).

INTERVIEWS – ORGANIZATION AND PROCEDURE

In total, 8 interviews were carried out with households at the Aarhus pilot site. These were carried out in two rounds and with two different interview guides:

1. Interviews with five households taking part in UC5 was carried out between 1st and 23rd of April 2020. These interviews focused on the **household members' experiences with the DR heat trial**.
2. Interviews with three households were carried out between 24th of June and 1st of July focusing on the interviewees experiences with the **RESPOND mobile app** (UC1) **and auto-consumption** (UC6).

The interviewed households were selected strategically to ensure a diversity in the sample with regard to age, occupation, gender and family composition. This was achieved, as none of the invited interviewees refused to participate in an interview.

Most interviews were carried out using normal Skype calls. Two was done via call to regular phone via Skype as the interviewees preferred this. All interviews were recorded. The interviews typically lasted between 50 and 60 minutes each. On basis of the recordings, a detailed summary (2-4 pages) was made for each interview. This summary formed the basis for the later analysis of the interviews.

INTERVIEW GUIDES

The interview guides used for the two rounds of interviews can be found in Annex 3 (UC5) and Annex 4 (UC1 and UC6).

2.2.2 MADRID (SPAIN)

USE CASES

At the Madrid pilot site, three use cases were trialed. Here follows a brief description of the use cases.

UC1 Mobile app providing energy data feedback to households

The purpose of the UC1 in Madrid pilot site was to evaluate the users' experience with RESPOND app and the users' own recommendations for possible further improvements.

The use case started at the beginning of February 2020, when the participants were provided with the log-on credentials to access to the app.

Eight of the eleven Madrid pilot households took part in UC1 (M00, M01, M02, M03, M04, M06, M10 and M12). Three households (M05, M07 and M13) were not included in the use case for two reasons: Firstly, because of their age. The first two participants are elderly persons, and at the time of the first set of interviews they were not able to participate in the demonstration activities due to the Covid-19 circumstances (they were worried about the pandemic and their health). They also remarked that they would not use the app due to their difficulties using technology. The second reason why the three neighbours did not finally participate in the trial was because they were not clients of Fenie Energía, so it was not possible to intervene in their electricity bills

changing prices and compensating them for the electrical consumption time shifted to the free hours.

The impact of the RESPOND app in the users' behaviour and the engagement level of the participants have been measured from two different points of view: On the one hand, from a technical point of view, as RESPOND partner TEK checked the status of participants login and the status of participants' downloads of updated version. On the other hand, from a qualitative point of view, the local partner responsible of the pilot (i.e. FEN) through the organization of interviews, obtained feedback about the impact of the RESPOND app in the users' behaviour.

At the beginning of February 2020, the RESPOND app credentials were distributed among the 11 Madrid pilot participants. Basic functionalities of the RESPOND app were available. During the following months, updated versions were implemented by TEK in order to improve the interfaces and functionalities. Once the participants had access to the app, a period was left for them to have a first experience with it. At the end of May 2020, FEN did individual interviews by phone calls with the participants with the aim of having a clear picture of their level of engagement with the app. The results of the interviews showed a low level of engagement with it. Also, the feedback about their preferred medium to receive notifications was informative. In addition, in relation to UC7, it was useful to collect their feedback about the happy hours of two hours a day (3-4 pm & 10-11 pm).

At the end of July 2020, FEN did a new round of individual interviews by phone calls with the participants with the aim of getting new feedback from them. Telephone calls were found out to be the most effective channel for communication between FEN and the participants. After the first interviews, the participants had a clearer understanding of the ongoing demonstration activities. In relation to UC7, by the time of the second interviews new happy hours were implemented (3-5 pm & 10-12 pm); financial incentives were already visible in their electricity bills. The interviews showed more favourable conditions for the users to time shift appliances: they were more engaged than before and additional valuable information in regards to their habits and difficulties to change electrical consumption routines was obtained.

UC7 – Price-based DR for electricity consumption

The purpose of the UC7 at the Madrid pilot site was to flatten the consumption curve. FEN measured electricity consumption in the different dwellings and analysed how users respond to price signals (incentives). For this purpose, the Madrid pilot households could see their real-time consumption and receive notifications with the price signals and incentives:

- First, we studied how users respond to long periods (up to 14hours a day) of free energy.
- Then, we measured their reaction to happy hours, during which energy was free for one or two hours.
- Finally, we analysed their response if we paid them through incentives to reduce their consumption at certain times.

The notifications were sent through different communication channels: the RESPOND app, text messages, emails and phone calls. The impact of the different channels in the users' behaviour was also analysed.

Eight pilot households took part in UC7 (the same as took part in UC1). The remaining three households were not included due to the same reasons as described earlier in relation to UC1.

UC7 had a duration of 10 months (since the end of November 2019 until the end of September 2020). Prior to the start of the UC7 trial, an analysis of the community consumption was made. The general meter indicated a peak of consumption one hour before the proposed happy hours, so by asking the users to time shift appliances such as washing machines, dishwashers and air conditioners etc., they could get economic benefits, as well as FEN could redistribute the consumed energy along the day.

The use case can be split into four different periods (a, b, c, d) based on the duration of the "happy hours" time slots. First, a starting period, where the households were offered a tariff with two fixed prices (periods a and b), then the free happy hours' time slots were considerably decreased from 14 to 2 hours a day (c), and finally we implemented the households' feedback from the first round of interviews by increasing the happy hours' time slots from 2 to 4 hours a day (d).

- a) Nov. 2019 – Mar. 2020: 14 hours of free energy a day (10 pm – 12 am) [Feníe Energía Winter DH Tariff. See *Figure 1*].
- b) 1-26th of Apr. 2020: 14 hours of free energy a day (11 pm – 1 pm) [Feníe Energía Winter DH Tariff. See *Figure 1*].
- c) 27th of Apr. 2020 – 31st of May 2020: 2 hours of free energy a day (3-4 pm & 10-11 pm)
- d) 1st of June 2020 – 30th of September 2020: 4 hours of free energy a day (3-5 pm & 10-12 pm)

Figure 1. Feníe Energía DH (time discrimination) tariff with two fixed prices for Winter and Summer (the figure shows a fridge sticker distributed to the participating households)

UC8 Maximise exploitation of DHW RE resources by sending app notifications to households about when it is best to consume DHW

For UC8 at the Madrid pilot site, solar thermal panels were installed on the roof of one of the community buildings for DHW production. Thanks to this the consumption of gas in boilers to heat the water could be reduced. Furthermore, it was originally planned that the RESPOND app would notify users about when to consume DHW in order to optimize the solar thermal production and consumption. However, UC8 was not carried out as planned due to several technical issues related to the gathering of data (see also RESPOND deliverable D6.5 *Best practices and lessons*

learned). Due to this, quantitative validation was not possible. Instead, a qualitative validation was done from a theoretical perspective through interviews with the pilot households in which they were asked about a hypothetical scenario about receiving app notifications on when it is best to consume DHW. In addition, the interviews included questions about the households' habits and experiences since the installation of the solar thermal panel, their willingness to time shift DHW consumption (mainly showers) with the aim of optimizing the use of solar thermal panels as well as their willingness to invest in the thermal solar system. Nine of the eleven Madrid pilot households took part in the interviews (M00-M04, M06 and M10-M13).

INTERVIEWS – ORGANIZATION AND PROCEDURE

Three rounds of interviews were made with Madrid pilot households:

1. Interviews about **electricity DR experience from 27th of April to 10th of May and experiences with mobile app** (UC1 & UC7) carried out at the end of May 2020.
2. Interviews about **RESPOND app and electricity DR experience from 1st of June and onwards** (UC1 & UC7) carried out at the end of July 2020.
3. Interviews about **DHW - solar thermal system** (UC8) carried out at the end of August 2020.

Interview guides for these three rounds of interviews were prepared by FEN on basis of the guidelines prepared by AAU (Annex 1) and in dialogue with AAU.

With regard to the choice of medium for conducting the interviews, it was decided to use telephone calls (without recording). The main reason was that not all the households had an account and were comfortable with Skype or other platforms, so telephone calls were thought as the most practical channel for the households.

Participants for the interviews were households that participated in the demonstration activities and had access to the RESPOND app. In addition, it was decided to interview only households who had Feníe Energía as energy supplier, so it was possible to play with their energy prices and actually remunerate them when an action was achieved.

There was a diversity in the sample of interviewed households, with a balance regarding the age (old and young persons), gender (males and females), occupation (adults working and adults retired) and families with and without children at home.

The interviews had an average duration of 15 to 30 minutes. During the interview, the interviewer was taking notes in the local language (Spanish) and afterwards the answers were summarized and analysed in written English and submitted to AAU for final analysis.

Finally, some methodological reflections on how the Madrid interviews went:

Interviews made by telephone calls allowed us to be able to interview a high number of participants, so diversity was ensured and selection biases were avoided. The format ensured that elderly households easily accepted to be interviewed. A different method, e.g. Skype, would have left out all the occupants who do not have a Skype account (which is a high number in the case of the Madrid pilot site). However, it was not possible to record the interviews and only one interviewer participated. A different method, e.g. Skype, would have allowed the record of the interview.

INTERVIEW GUIDES

Three interview guides were developed for the Madrid pilot interviews (one interview guide for each round of interviews). The interview guides are included as annexes to this deliverable (see Annex 5-7).

2.2.3 ARAN ISLANDS (IRELAND)

USE CASES

UC1 Mobile app providing energy data feedback to households

The use case UC1 objective was to analyse how access to data through the RESPOND app would impact user behaviour. The main idea was to understand if, after having access to the app data, the costumer changed in some way the consumption during the period without any active message asking them to do it. For the qualitative analysis, a few specific questions about this topic were included in the interviews with the participants, for understanding the consumption pattern differences before and after having access to the technology.

UC2 Maximise auto-consumption from PV panels by sending mobile app notifications to households about optimal time to consume electricity

The objective of use case UC2 was to maximize auto-consumption during periods where there is a peak in energy production. The day before the event, the hourly prediction model of RESPOND estimates the PV production for the next day. This information is used to send a message to the pilot households with PVs if a pre-defined threshold is achieved.

UC3 Optimal profile of use of heat pumps

The aim of use case UC3 was to maximize PV self-consumption by generating an optimal profile of use for heat pumps. This use case could be performed in different ways, such as fully automated operation of the heat pumps, which can achieve better energy savings and does not rely on the user's behaviour, or manually operated. However, for technical reasons and due to Covid-19, it was decided not to carry out this use case. Instead, it was validated by using the Building Simulator and Option D of IPMVP (Simulations). Further information about it can be found in RESPOND deliverable D6.5.

UC4 Motivate households to peak-shave consumption during grid peaks by use of mobile app notifications

Use case UC4 was designed to evaluate the pilot households' willingness and flexibility to decrease the carbon emissions during one hour in one day of the week. The main idea of the use case was to send a manual notification one hour before the peak consumption of electricity in Ireland, asking people to decrease the usage without any financial incentive.

INTERVIEWS – ORGANIZATION AND PROCEDURE

There were six interviews carried out on the Aran Islands between 5th and 18th of August 2020. The selection of the households for the interviews was made based on the involvement of the participants with the project and their availability during the period. The duration of the interviews was in average 30 minutes. They were recorded and summarized by the pilot responsible without including information that may identify the participant.

The interviews were designed by a participant of the project (ARAN) on basis of guidelines provided by AAU, and was realized by the pilot responsible; a person who knew the participants and who they could be comfortable to give the opinion about the project.

INTERVIEW GUIDES

The interview guide used for the six interviews (which covered all Aran Islands use cases) can be found in Annex 8.

2.3 QUESTIONNAIRE SURVEY

This section applies to the Aarhus pilot site and the UC5 on load-shifting district heating by central (remote) control of radiator thermostats.

A questionnaire was developed and applied in the ten participating dwellings during the ten test weeks. The questionnaire focused on the tenants' experienced problems and satisfaction with normally occurring thermal comfort issues. That is problems with too low or high temperature, draught (annoying air movement), and problems with the new thermostats or the (existing) radiators. The tenants were asked to indicate when (day and time of day) and in which room they experienced problems. A question about how satisfied the tenants were with the temperature conditions was also included. In an attempt to identify unforeseen relevant issues, a series of open questions were included, where tenants could provide input in their own words. The original questionnaire in Danish is presented in Annex 9 and a version translated into English is shown in Annex 10.

Since the DR actions took place only on weekdays, Monday to Friday, and not during the weekend, the tenants were asked to answer the questionnaire Thursday or preferably Friday each of the ten test weeks to assure that they had been present during several DR actions, before answering. Prior to the survey, tenants were individually informed about the coming questionnaire survey by email and personal communication.

2.4 THE ANALYTICAL APPROACH

The qualitative interviews were analysed by AAU on basis of the summaries of the individual interviews of the three sites (the summaries are not included in this report due to ensure the anonymity of the interview participants). On basis of the summaries, analytical themes and

observations were identified, and these are reported in this deliverable (next chapter). In the analysis, focus has primarily been on details or phenomena that has occurred in several interviews from the same site or across sites. In this way, the analysis focuses on phenomena that appears to have a more general relevance.

3. ENGAGEMENT IN USE CASES: FINDINGS AND ANALYSIS

This chapter presents the findings from the qualitative interviews (and the questionnaire survey related to UC5). The chapter is organized into subsections analysing the user engagement in the RESPOND use cases separately. Though, the analysis of two use cases (UC2 and UC6) has been combined into one subsection (see section 3.2), as there are many similarities between these two use cases. Combining them into one section, and analysis, also makes it possible to compare the findings of the two use cases. Furthermore, as earlier mentioned, one of the originally planned use cases (UC3 – Optimal profile of use for heat pumps) was never realized (but replaced by simulation), and it is therefore not included in this analysis.

3.1 UC1 – MOBILE APP PROVIDING ENERGY DATA FEEDBACK TO HOUSEHOLDS (MADRID, ARAN & AARHUS)

In this section, focus is on how the users received the mobile app and their general experiences and perception of it (including recommendations for improvement). However, the analysis also look at specific uses of the app for other use cases (see following subsections).

This section is structured according to the overall analytical observations emerging from the interviews.

3.1.1 ONE APP USER PER HOUSEHOLD – MOSTLY A MALE ADULT

In total, 17 pilot households have been interviewed about their experiences with downloading and using the RESPOND app (8 in Madrid, 3 in Aarhus, 6 on Aran Islands).

Without any exceptions, the interviews show that only one person per household is using the mobile app – and this person is most often a male adult of the household. Of the interviewed households, in only five cases a woman has downloaded and/or is using the app. Two of these are living alone, while for the remaining three women, one tried to download it once (Aa16), but gave up on using the app, while two women did use the app regularly (AR04 & M01). One of these women lives together with her husband and their two pre-teenage children in the Madrid pilot site (M01). In the interview, she stated that she is the member of the family who is most conscious about the RESPOND trial and is the most engaged in this. She is in charge of running washing machines and dishwashers and is the one who is behind the rest of relatives motivating and promoting energy savings. The other regular female app user lives on Aran Islands (AR04) and she does not share or discuss the information from the RESPOND app with her husband.

Thus, the interviews show that it is mainly male adults who download and uses the app, which indicates a strong gendering of RESPOND app users. Also, it is interesting that only one person per household downloads and uses the app. The only exception from this is a household with an older couple in Aarhus (Aa16), where the man was the regular user of the app, while his wife once tried to download the app to her phone, but eventually gave up on using it. The fact that only one person in the household is using the app might have important implications on the efficiency and success of demand response solutions like those tested in RESPOND. In households with more

than one household member, several persons will typically be involved in everyday practices related to energy consumption (e.g. cooking, cleaning, laundering etc.). Following from this, communication with and feedback to just one member of the household (e.g. the husband) will limit the impact of energy feedback and DR notifications. Especially if the household member using the app is not communicating the messages and information to other members of the household.

Several of the interviewed app users explain that they talk with other family members about the messages and information received from the app. For example, the male interviewee from AR01, who is in his 70ies, explains that he speaks to his wife about the app to let her know if there is going to be an increase in PV generation as she is the one that operates the main household appliances. However, the children do not know about the app, and the interviewee does not discuss appliance consumption with his wife in more general terms. Another example is from the interview with the previously mentioned older couple in Aarhus (Aa16). Here, the female resident is wondering whether the fact that she does not use the app herself, but gets information from her husband, influence her hesitant attitude towards time-shifting consumption. She says: “It might make a difference, because – I have to admit that I place the responsibility on M [her husband] – now, M reads it aloud in the background that ‘well, today we can wash …[laundering or dishwashing] so and so’. ‘Well, well’, I think (laughs). ‘You just go ahead’ (laughs). It might be an idea if we both have it [on our phones].”

On basis of the interviews, it can be concluded that it is likely that app solutions like the one trialled here is only in contact with one person of multi-person households. This might be a limiting factor for the success and impact of such apps, as the energy consumption in homes depends on the activities and engagement of all members of the household.

3.1.2 Frequency of use

Regarding the frequency of use (i.e. how often the interviewees opens the app), the answers are distributed as follows:

- Not downloaded: 1
- Only used one time (after download): 2
- Less than weekly: 5
- Weekly: 3
- Daily: 3
- Not known: 3

The answers indicate that except for a few dedicated users, who uses it on a daily basis, most interviewees are irregular users who opens the app on a weekly (or less) basis.

Two interviewees have only used the app once. In both cases (AR02 & AR08), the interviewees explain that their disappointment with their first experience with the app kept them from using it again. The interviewee of AR02 explains, that she has opened the app once, but she could not see what she could do with it, so she decided not to use it again. She thinks the app “wasn’t straight forward and simple”. In this case, the refusal of further use should also be seen in context of her general attempt to reduce her presence on social media, and use of her mobile phone in general, as she tries not to use anything she does not need (in an attempt to reduce digital

information and disturbance). In the case of AR08, the interviewee was disappointed that even if the app at first sight did look simple and user friendly, she kept receiving errors. She had tried to click into the tumble dryer section of the app, but she got the notification that "RESPOND isn't responding", which she found ironic. Both cases show the importance of the quality of the user's first experience with the app (i.e. the first time it is opened). If this is a negative experience – e.g. due to incomprehensible design or technical errors – this can heavily affect the users interest in using it again later (see also later analysis of the users' experience with the intelligibility and reliability of the app).

The three interviewees who report to use the app daily are all males. The app features that these interviewees primarily use are: Checking temperatures of rooms (M00, M12, AR06), consumption of devices (M00), comparison of own energy consumption with neighbours (M00) and monitoring the energy consumption for the heat pump (AR06).

3.1.3 THE ROLE OF AGE

Although with important exceptions, older interviewees tend to find it more complicated to download and use the app than younger interviewees[1]. This indicates that age plays a role in the adoption and use of app-based DR and energy feedback solutions, which should be taken into consideration when designing such solutions.

Some of the older interviewees found it difficult to download the app in the first place. One example of this is from Madrid (M04), where a woman in her 80ies explains that she did not download the RESPOND app on her mobile phone because she is not very familiarised with technology (lack of technology competences) due to her age. She did try to download the app once, with the help of a neighbour, but it could not be installed due to lack of memory on the phone. Instead, her adult son, who lives at a different place, has downloaded the app on *his* phone, and he is informing her about the notifications he receives on his phone. Except from this, the interviewee does not know which app functionalities he uses. She explains that she finds all matters related to the app very difficult due to her age and her non-familiarity with this sort of technology, but she stated that she is a very curious person despite of her age and was willing to learn and use the app. Another Madrid interviewee (M10), in his 60ies, explains that he does not use the app that much, because he does not find it easy to use the mobile app. Similarly, Madrid interviewee M03 explains that he finds it difficult to use the app, but adds that even if he is an old person, he would like to learn about new technology.

However, even if we find an overall tendency that older people are having more difficulties with downloading and using the RESPOND app than younger people, there is an important and significant minority of older people who actually succeed in using the app – and in some cases with high frequency. This shows the importance of not over-simplifying the role of age. Actually, among the three interviewees who uses the app on a daily basis (see section 3.1.2), two of them are males in their 70ies. And the husband of another older couple, Aa16 in Aarhus, is a further example of a frequent user of the app, who finds the app easy to navigate and in particular likes

[1] Within the academic literature on information and communication technologies, this has been termed the age-based digital divide. However, as pointed out by Barbosa Neves et al. (2018), it is important to avoid a too simplistic understanding of elderly as one homogenous group.

to compare their own consumption with that of their neighbours. None of the here mentioned interviewees have a background within engineering or similar technical professions.

In conclusion, the analysis shows a tendency that older people more often than younger lack the needed skills and competences to download, install and use mobile apps like the RESPOND app. However, the group of elderly is a diverse group and it seems to include a sub-group of persons who find new technological solutions interesting and possess the skills (and time?) to use such solutions. Therefore, it is not advisable to abandon this group in future DR programmes, but it should be consider whether DR initiatives should 1) put extra efforts into ensuring a design of apps that makes these easier for older people to use and/or 2) specifically target the subgroup of older people who have the skills, interest and time to adopt and use new technical solutions.

3.1.4 Overall user experiences of the app

This section focuses first on the interviewees' overall experience with the app, while more specific uses of the app (e.g. for comparing own electricity consumption with neighbours) are detailed in separate sub-sections as well as in relation to the analysis of other use cases (UCs).

With regard to **intelligibility** – i.e. how easy it is felt to navigate in the app and understand the information presented – there is a tendency across the interviews that the users experience it to be complicated and difficult to understand what is shown by the various pages. For instance, one of the interviewed on Aran Islands explains that in some of the carts "it's not clear, for example, what the vertical axis is measuring" (AR01). He further adds that:

> "it is not clear what comparing to my neighbours means? Is it everyone else in the project? Or just my nearest ones? It would be good if there was a help section in the app where everything is explained in detail and also advice is given. The Home button opens a page that I find the most difficult. It's difficult to understand what it's telling me." (AR01)

This interviewee finally adds that the text and charts are small in size and can't be expanded with his fingers, which makes it difficult for him to read it without his reading glasses.

The experience of this interviewee is shared by several other interviewees. For instance another Aran Islands' interviewee (AR04), who tells that she does not think the app is user friendly and that the information is not laid out in a clear manner. Similarly, the Aarhus interviewee Aa05 thinks that the app is not "intuitive" to use and can be difficult to navigate in. Sometimes, one must select from a long list of options, which can be difficult – partly because it is not always easy to understand what the different terms mean.

This said, there was also a number of interviewees who in general were happy about the app and found it easy to use and navigate. This includes, among others, one Aarhus interviewee (Aa16) who tells that he did not find it difficult to navigate the app and that he (and his wife) would be interested in continue to use the app also after the conclusion of the RESPOND trial (if it was possible). Similarly, the Aarhus interviewee Aa19 also find the app quite intuitive, though he thinks that it contains too much information and that the graphs tend to be too "technical"; "you need to find it funny to sit and be 'nerdy' with it", he says. I.e. that to get the most out of the app, he thinks that one should be the dedicated type of person who likes to spend much time on exploring the information provided by the app. Another content user of the app is the Madrid interviewee M00, who checks the app very often and finds the information on temperature and device consumption

useful and also checks the neighbourhood comparison graphs; he thinks the interface looks quite good.

As the above illustrates, there is a diversity across the interviews with regard to how intelligible the RESPOND app was experienced by the users, though there is a bias towards the more critical voices. In particular, several found it difficult to understand what the different graphs show (e.g. units of y-axis).

Another relatively widespread criticism relates to the **speed and responsiveness** of the app. Across all sites, several persons find the speed and responsiveness of the app as too slow. Waiting even just a few seconds for updating a screen is felt as too long by many. And some even give this as a key reason for giving up on using the app. For example, Madrid interviewee M02 explains that even though he finds some features of the app useful (e.g. weather forecast and neighbour comparison), he does not use it frequently because the app is a bit slow. Similarly, Madrid interviewee M06 tells that he thinks the app was very slow and when trying to look for any kind of information, it was "thinking" for a long period of time. Another example is Aarhus interviewee Aa05, who finds it frustrating that the app is slow to update pages; often, he only has a little time to use the app, and then he does not manage to get much information because it is too slow. This is actually his main complaint about the app; he thinks that even if it only takes a few seconds, one has become used to very fast mobile apps nowadays, which makes the RESPOND app feel very slowly in comparison. These examples demonstrate that speed and responsiveness are critical for the experience of DR and energy feedback mobile apps like the one trialled in this project. Modern app users lack patience and the "tolerance threshold" is extremely low when it comes to the time it takes to load and update pages. Optimizing speed and responsiveness should be a key design criterion in the development of this type of mobile phone applications.

Finally, some interviewees comment on the **reliability** of the RESPOND app. Several have experienced app errors, bugs or that pages cannot be loaded. This is experienced as annoying and is also something that in some cases contributes to making people abandon the use of the app. For instance, Aran Islands interviewee AR03 tells that that in addition to being slow, the app crashes on him on a regular basis depending on what features he is trying to use, and this discourages him to use the app often. Some of these problems appears to relate to problems with measuring data from sensors and/or issues related to the transmission of data via the gateway etc. Similar to speed and responsiveness, a high level of reliability appears to be a critical criterion for the design of DR and energy feedback applications.

Many of the above stories and negative experiences related to intelligibility, speed, responsiveness and reliability is, of course, to be expected from an experimental trial of newly developed applications as the RESPOND app. For example, some of the features of the RESPOND app (e.g. comparing consumption with neighbours) depend on large (distributed) datasets and extensive calculation, which involves risks of creating delays and reduce the speed and responsiveness of apps. For this reason, much of the critique might not be surprising – but it nevertheless points to a number of key issues that needs to be solved if future DR and feedback solutions are going to be appealing to the users and to avoid user dropouts.

With these general observations in mind, the remaining part of this analysis of UC1 will focus on the app features that were most often used by the pilot participants and, finally, the recommendations from users regarding possible improvements of the app.

COMPARING CONSUMPTION WITH NEIGHBOURS

One of the features of the app that seems to attract most attention is to compare one's own energy consumption with that of the neighbours. This feature is used by three of the Madrid interviewees and two of the Aarhus interviewees (but not reported by any Aran Islands interviewees). This supports the theoretical outset of the RESPOND project that comparing one's consumption to that of others can be a lever for engagement in DR actions (see RESPOND deliverable *D3.2 RESPOND user engagement strategy*). Several of the interviewees also put some efforts into interpreting differences between their own and their neighbours' consumption. One example of this is an older couple in Aarhus (Aa16), who finds it funny to compare their own consumption with that of their neighbours. Actually, they believe that the comparison chart in the RESPOND app shows the energy consumption pattern of their closest neighbour (in fact, the app shows an averaged consumption profile for all participants in the pilot). This misunderstanding leads them to speculations on how to explain differences between their own consumption and that of their neighbour, since they have some knowledge about their neighbours daily activities. The husband thinks it could be to talk with their neighbour about why his consumption looks as it does. The husband also thinks that the energy consumption comparisons can help trigger considerations about how one might change one's own consumption and save energy. Another Aarhus interviewee tells a similar story (Aa05): This interviewee has primarily used the app to compare with neighbours, and he has noticed that their consumption is in general above that of the other households. As a result, they have been around in the house to turn off appliances and light – "small things" that they can turn off to save some energy. When asked, why they do this, he answers:

> C: You [meaning himself] have compared it with the others and thought 'do we have an over-consumption of power when it is actually unnecessary – when the others [RESPOND households] can manage for less?'
>
> Interviewer: So, the thing about comparing oneself with others, it means something, you might say?
>
> C: Well, yes it does. Well, how much power do the others need – not that it has to be some kind of competition, necessarily, but to see if there are areas where we also could turn down in order to get on the same [energy] curve as the others.

The family has started to turn off lighting, when not necessary, and their TV boxes (before, they were turned on 24/7, but now they have changed the settings so it turns off after 4 hours with no use) and computers (if not used). When asked what difference the app makes, he answers that the app provides a visualization of their own consumption compared to others. This makes it easier to compare oneself with others. In addition, he also refers to a general trend in society with more focus on energy consumption and climate. He thinks that this might also influence their (changed) behaviour – as well as the incentive of saving money from reduced energy consumption.

Thus, the interviews showed that the neighbour comparison feature attracted some attention among a subset of the interviewees (about one-third), particularly in Madrid and Aarhus. Compared to other app features, this feature was the one with most users. This supports that

including information about how households compare to others with regard to their energy performance is a key feature of successful app solutions.

MONITOR ONE'S OWN ENERGY CONSUMPTION

Another app feature that was used by several was the pages monitoring the energy consumption of the household. One example of this is the Aran Islands interviewee AR06, who tells that he likes to check the consumption on a day where he might turn up the temperature and the heat pump is operating, compared to the day before when it may not have been on at all. He tells that he likes to see "how efficient it [the heat pump] is and how much energy I'm using". In other words, this is an example of increased energy awareness, which might turn into a more energy efficient behaviour. Another example is the Aran Islands interviewee AR03, who tells that he mostly uses the app on particularly sunny days, or the opposite, if it was a very bad day. He would use the app mostly to compare sunny/cold days; he followed the consumption of the heat pump and compared how hard the heat pump was working on cold days compared to sunny days. He also likes that he can follow the consumption of individual devices. From the Madrid pilot, one interviewee (M03) said he mainly uses the app to check consumption and that he finds it useful from a consumption control point of view.

Even if not as much used as the neighbour comparison feature, the feature of monitoring one's own consumption appears to be among the most often used features of the app. However, the interviews do not provide any examples of how this might have led to changed habits and energy savings.

AIR HUMIDITY AND TEMPERATURE

Room temperatures and air humidity was a relatively used feature of the app (by 4-5 interviewees). Several interviewees checked the room temperature regularly, while one interviewee (Aa05) reports that he has used the information on air humidity. The latter explains that he has two aquaria in his living room and that he wanted to see how they affected the indoor air humidity – and to see if he needed to air out some more to keep the humidity low. In general, the humidity was fine, so there had not been any need for extra airing. However, one time the measured humidity was high, and he then realized that he had forgotten to put back the covers on top of the aquaria (which led to increased evaporation to the air). However, apart from this, he has not used the air humidity page for other things (he is also not sure about which room is displayed in the app, as there are several air humidity sensors installed in the home). This interviewee also suggests that it would be smart if the app could provide notifications in situations where the humidity becomes too high (and one needs to air out). That could help people to improve their indoor air quality.

WEATHER FORECAST

Finally, a few interviewees report that they regularly or sometimes use the weather forecast of the app. It is not clear from the interviews whether they prefer to use the weather report feature of the RESPOND app instead of another weather forecast app. But it seems like the weather report is

a positive, additional feature to a small group of interviewees, while it does not seem to annoy the other interviewees. One interviewee (AR03) even would like updates (notifications) on weather reports, which seems to be linked to his existing practice of regularly updating the settings of his heat pump depending on the season and the weather. On basis of this particular interview, it seems as a relevant additional feature, for this particular group of people who regularly adjust their heat pump settings, to get e.g. weekly notification with a weather forecast for the week ahead.

IDEAS AND RECOMMENDATIONS FOR APP IMPROVEMENTS

During the interviews, the interviewees were asked about their suggestions and ideas on how the app could be improved. Here follows a summary of the recommendations made by the participants, ordered by how many interviewees who made the specific recommendation (i.e. the most often suggested recommendations being presented first).

- Faster and more responsive app: As already indicated in the beginning of this sub-section, several felt that the app was not loading and reacting pages fast enough. Thus, a widespread recommendation was to make the RESPOND app faster. As the Aarhus interviewee Aa05 tells, even a few seconds delay can be felt like a long time nowadays where people have got used to fast working internet applications.
- More reliable app: Another often mentioned recommendation was to increase the reliability of the app. Here, there seems to be referred to two types of issues: First, some people experienced that the app sometimes fails or break down. However, this did not appear to be a prevalent problem. Probably more important, several reported issues with loading data from sensors or meters, which prevented them from having use of a number of pages/features in the app. This problem is likely to be related to the data transmission infrastructure “behind” the app. This also illustrates the technical challenges in building an advanced “eco-system” based on data flows from buildings/devices/meters to central databases and back to the households and the users’ mobile phone app. In this way, the recommendation of ensuring higher reliability is not limited to the app itself but relates to the entire RESPOND system.
- More intuitive app: Here, the opinions were slightly mixed. Some found the RESPOND app intuitive and easy to navigate. However, there were more interviewees who recommended a more intuitive app. They typically found the level of information too high and/or found it difficult to understand what type of data that was visualized in charts and with what units.
- Energy consumption displayed in local currency instead of Wh: Several noted that they found it difficult to understand the unit of Wh, which was used to display energy consumption in consumption charts. They would have preferred if the energy consumption had been shown as costs in their local currency (euro or Danish Kroner).
- Would be relevant to see the impact of one’s performance or new behaviour on energy consumption: A few suggested that it would be ideal to be able to see or track the energy implications of one’s changed behaviour. For instance, how much does one save from turning off the light more often? Or how much does time shifting of electricity consumption to daylight hours help increase the share of local PV power in one’s electricity consumption? The latter functionality was actually added to an updated version of the app.

However, it was not possible to update the app with this functionality before rather late in the trial, so the users' experiences of this was not properly evaluated in the interviews.

- Notifications about when one should air out the home: A few also suggested to include notifications on when it is advisable to air out the home; e.g. in cases with a too high air humidity. This, combined with the observation that several also used the app to check their indoor temperatures, indicates that there is a relatively widespread interest in information on the quality of the indoor environment and services that can help improve this.
- Include water consumption data: It was suggested by a few interviewees to include also water consumption data in the app. This might indicate that people tend to associate water and energy consumption as belonging to the same category, i.e. the resource consumption of the home.
- Would be good to decide level of detail: Some interviewees commented that the app provides many types of data on a rather high level of detail. This probably also contributes to the feeling among several interviewees that it could difficult to navigate in the app and understand the information. Related to this, a few interviewees suggested that it should be possible for the user to adjust the settings according to wanted level of detail.

3.2 UC2 AND UC6 – MAXIMISE AUTO-CONSUMPTION FROM PV PANELS BY SENDING MOBILE APP NOTIFICATIONS TO HOUSEHOLDS ABOUT OPTIMAL TIME TO CONSUME ELECTRICITY (ARAN & AARHUS)

We have combined the evaluation of UC2 and UC6 into one analysis, as they both are based on issuing notifications to the pilot households with recommendations on when it is optimal to consume electricity from local PV panels (micro-generation). By combining the use cases in one analysis, it makes it possible to explore differences and similarities between how the participants experienced and reacted to the notifications. Also, it makes it possible to analyse what role the differences between the local settings (occupier-owned homes versus social housing association; island versus urban context) and differences in how notifications where issued. With regard to the former (local settings), the main difference is occupied-owned homes (Aran Islands) versus apartments in a social housing association (Aarhus) and rural island versus urban context. Regarding the latter (how notifications were issued), the main difference is that on Aran Islands, notifications with recommendations on when to consume electricity was limited to days when the electricity production of the PV panels of the individual homes was predicted to exceed 900 W (during the period from 1st of June to 30th of June 2020) and 600 W[2] (from 18th of July to 31st of August 2020). During the first period, in total 4 messages were sent to the pilot households, while during the second period 12 messages were sent in total. The Aran interviews were carried out between 7th and 18th of August, i.e. midway through the second period. Unlike on Aran Islands, app notifications were issued to the Aarhus pilot households on a daily basis. The notifications informed the residents about during which hours it would be best to consume electricity, i.e. in which hours the production of the social housing association's PV panels would peak according to predictions based on local weather data. Notifications was sent to the Aarhus households from

[2] Except for one house (AR02), where the threshold limit was 1100 W.

the 25th of May 2020 until the end of the RESPOND project (i.e. until September 2020). Until the 23rd of July, the notifications in general recommended consumption during most of the day hours (e.g. from 9 am to 6 pm), which was due the fact that the PV panels of the housing association generates more electricity than is locally consumed during many hours around midday due the summer period. However, as this does not represent a more typical use case during other seasons (in particular spring and autumn), the protocol was changed so from the 23rd of July and onwards, the recommendation was limited to the two hours of the day with maximum PV power production (which can shift between morning, midday and afternoon from day to day, depending on the weather predictions). The interviews with Aarhus residents about the app and their experience of the notifications were carried out before 23rd of July.

3.2.1 DO THE RESIDENTS TIME-SHIFT CONSUMPTION TO OPTIMIZE AUTO-CONSUMPTION?

The basic idea of UC2 and UC6 is to use mobile app notifications to engage the pilot households in time-shifting their electricity consumption to hours with maximum (excess) production of local PV power, either this being from individually owned PV panels of homeowners (Aran Islands) or collectively owned PV panels (Aarhus). The residents' incentives for doing this can be of different types, e.g. saving money, doing something good for the environment or for the local community. In the case of the homeowners on the Aran Islands, these have a direct economic incentive from increasing auto-consumption as this will reduce their electricity costs proportionally with share of their electricity consumption covered by their own PV power generation (they do not get payment for the PV excess electricity delivered to the grid). Thus, a strong financial incentive for auto-consumption might be expected on the Aran Islands. This is different from the Aarhus pilot site, where the PV panels are collectively owned by the housing association and where the individual households do not get a separate electricity bill reduction by increasing auto-consumption. Instead, the financial gains from increased auto-consumption is distributed among all tenants in the housing associations, which means that the economic benefit for the individual RESPOND pilot participants are small and is not directly visible. These details about the context of the Aran Islands and Aarhus pilot sites are important to have in mind in the following analysis of the interviewees self-reported practices regarding time-shifting consumption and their perceptions of the app notifications.

Of the six interviewed Aran Islands households, five report that they time-shift energy consumption on a regular basis. The interviewee of the remaining household (AR08) that does not time-shift energy tells that she was originally motivated to move her consumption in the interest of the environment, but the main reason for not moving consumption in time appears to be that she is not having her own PV panels (and therefore did not receive any app notifications related to UC2).

Of the five households moving consumption in time, two are on a night saver tariff (AR01 and AR06), which means that they save money if they postpone electricity consumption to the night hours. The interviewee of household AR06 explains that he encourages his wife to use the washing machine at night. In addition, he has set the heat pump so that it does not turn on at night if the outdoor temperature drops below a certain threshold. At first sight, this might sound counterintuitive as this household is on the night saver rate, but the interviewee had done calculations himself and found that by doing this, he would save on his electricity bills (and the

temperature of the home would only drop about 1 degree overnight). The reason for saving electricity was that due to lower outdoor temperature at night, the Coefficient of Performance (CoP) of the heat pump was much lower in the night than during daytime. This new practice was actually developed during the RESPOND trial with the help of the RESPOND app, which he had used to monitor the electricity consumption as well as the indoor air-temperature during the night. For this interviewee, the driving factor for moving consumption was to save money, as he feels that operating costs are a big factor for everyone and mentioned that "there's no point in telling you that it's going to be good for the environment if it's going to take the food off your table … it as to be economically viable". That said, the interviewee recognises and is happy that he is contributing to the environment by managing his electricity consumption responsible. The other household on night saver tariff (AR01) is having a PV panel, and this household time-shifts consumption both to night hours and midday hours (on sunny summer days). The interviewee explains that they would generally delay the washing machine, dryer and dishwasher to turn on at night, unless they are using it in midday hours during a high PV generation period. He further explains that their reason for having PV panels is to help the environment and reduce their carbon footprint. However, the regular management (time-shifting) of electric appliances is to save money for the household.

For the five households time-shifting consumption, all reports to time-shift use of washing machine, while the dishwasher is the second most often time-shifted appliance (see table below). Only few time-shift tumble drying, though this likely reflects that the interviewed households only rarely use tumble dryers. Other mentioned energy-consuming activities and appliances time-shifted are: Mowing the lawn (electric lawnmower), showers and heat pumps. Compared to the international research on demand response, it is a bit surprising that two households are time-shifting their showers, as this is typically seen as an activity which is difficult to shift in time. However, in both households the residents do not have jobs with regular working hours, which might explain their flexibility with regard to time-shifting their showers.

TABLE 2: TIME-SHIFTING ACTIONS OF ARAN ISLANDS HOUSEHOLDS

	Dishwasher	Washing mach.	Tumble dryer	Lawn-mower	Showers	Heat pump
01 PV + nightsaver	X	X	X			
02 PV		X	X	X		
03 PV	X	X			X	
04 PV	X	X			X	
06 Night saver		X				X

All five interviewees doing time-shifting mention saving money as a reason for doing this. Two of the interviewees report this as the only reason (AR01 and AR06), while one interviewee also mentions environmental concerns as important. One interviewee (AR03) seems also the pleasure of "streamlining" the consumption as motivating, i.e. optimizing the energy consumption and timing with regard to utilizing own PV power generation. Finally, one interviewee (AR04) thinks of

the PV generated electricity as a form of “free energy”. However, despite some diversity in reasons for moving consumption, the financial motive of saving money appears to be the dominating incentive for this group of households.

The four interviewees with PV panels installed at home had taken part in UC2 with app notifications informing them in advance of days with a predicted high PV power generation. Three of the four interviewees remembered to have received app notifications about this, while the fourth (AR02) did not remember this (however, she was from the beginning reluctant with regard to using the app, partly because she wants to reduce the use of digital media in daily life, so she might not even have had the app installed). Overall, the three interviewees, who remembered receiving notification, did not find them particularly useful. One interviewee (AR01) explained that he would immediately pass the information from the PV generation notifications over to his wife and that he did not check if she followed through with the actions or not. He stated that this was more of a reminder as his wife is already aware that they should use the appliances when the sun is shining. Further, he did not consider utilizing his heat pump during the high PV generation times because it is automatic and he never messes with the controls. He was aware that he could suggest to the family to have showers at those time, but did not as they all like to have showers at times that are convenient to them, and would not change this based on the notifications. Another interviewee (AR03) noted that he has a lot of applications on his phone and he did not pay particular attention to the RESPOND notifications he received. He said, as he is out a lot of the time, he thinks it would be more useful for someone that is at home most of the time to have the app and receive the notifications, although that was not possible in his case. The third interviewee (AR04) said that she has a good idea herself about her PV generation. She already knows that on sunny days, her PV panels are generally generating energy from 8 am. She would generally think about her washing machine and dishwasher first upon receiving these notifications.

While the interviews indicates that the app notifications might have had a minor impact on the routines of the latter interviewee (AR04), the overall picture is that the notifications did not do much of a difference to the existing everyday practices of these households. A likely explanation is that these households are already doing quite extensive demand response actions in order to utilize as much as possible of their own PV power generation. Before the start of the RESPOND trial, these households have adapted their routines to the rhythms of the solar power production – and the rhythms of the weather and seasons. As the interviewees of household AR01 and AR03 explained, they already know from previous experience that the PV panels generate much energy on sunny days. This resonates with previous studies of the behaviour of homeowners with PV panels, which show that the residents of such homes in many cases develops new routines after acquiring the PV panels in order to optimize the auto-consumption (Dobbyn & Thomas, 2005; Olkkonen et al., 2016). This is also termed “prosumers” in the literature. The time-shifting habits of PV owners is particular prevalent if the home is on a customer account settlement scheme that implies that they earn little or almost nothing from exporting the excess PV power production to the grid (Christensen et al., 2017). Such schemes work as an effective incentive to do extra efforts to move consumption to peak-production hours in order to avoid “wasting” the “free energy” by feeding it into the grid without any or only little remuneration. We find similar patterns for the Aran Islands homes with PVs. Because of the already established time-shifting routines, the app notifications do not provide much additional information to what the residents already know from practical experience and from following the weather changes.

For the Aarhus pilot and use case UC6, the three interviews focusing specifically on this use case showed a more mixed picture. The interviewed couple of Aarhus household Aa16, and older couple, tells that they have time-shifted their consumption for a long time, i.e. also prior to the RESPOND trial. They do this when they are staying in their second home (a summerhouse). Here, they have installed PV panels in the second home about five years ago, and as they are only getting a small remuneration from exporting excess PV power to the grid (compared to the price of buying electricity from the grid), they aim at moving as much electricity consumption as possible to the daylight hours. They time-shift use of washing machine and oven (when baking) and, to some extent, also heating. When at home in their apartment in Aarhus, they do not put the same level of efforts into time-shifting their consumption, but they attempt to move clothes washing to daylight hours. The couple explains that the difference in level of efforts is likely because they do not have the same level of personal financial gain when moving consumption in the apartment. Here, the financial gains from increasing auto-consumption is spread on all tenants in the housing association, which makes the individual gain negligible. When asked about the app notifications, they answer that they do not think they make a big difference; their current behaviour is steered more by observations of the weather (sunshine) than by what the notifications tell them – and doing the laundering during daytime hours has become a routine. However, later in the interview, they notice that the notifications have made them more observant about the use of the dishwasher. The notifications, which are issued around 6 pm in the evening, have on several occasions encouraged them to postpone the start of the dishwasher from in the evening (after dinner) to the next day. The husband believes that the mobile app and the notifications might be useful in "educating" people to become more observant about time-shifting consumption. The interviewee from the other household (Aa19) tells, that they consume electricity when they have to consume it. Being a family with young children, he does not feel they have much flexibility with regard to time-shifting energy consumption. For this reason, he does not feel that they have had much use of the app notifications. He suggests that batteries for local storage of excess PV power would be a better solution than active time-shifting. The interviewee later mentions that more recently, they have changed the habit of starting the dishwasher in the evening to start it in the morning. He speculates whether the app notifications might have had an influence on this, though it might also be related to a change in his morning routines due to a job change. Like the previous couple (Aa16), this interviewee also thinks that if the financial gains from time-shifting actions were allocated to their household, rather than being spread across all tenants, they would be more willing to change routines. He thinks that if they had been homeowners with their own PV panels, they would have been more motivated for time-shifting their consumption. In addition, he would have liked more automated solutions for doing the time-shifting. Similar to the Aa19 household, the interviewee of the third household (Aa05) also thinks that it is difficult to move consumption due to lack of time flexibility being a family with small children. He thinks that time-shifting of consumption implies too much planning: "It's like – when you have got a fixed rhythm [of everyday life], you stick to that". Like Aa16, he also thinks that they might have been more motivated if they had saved money themselves. However, he also appreciates the idea of doing something for the common good of the community. Not only the common good of the housing association, but also for the wider society in relation to mitigate climate change. He thinks it must be a compromise between doing something for the common good, but without it being too inconvenient for oneself or one's family – and, in addition, one should be financially rewarded for changing daily routines. More generally, the importance of a financial incentive is pointed out by

all interviewees, though the husband of the older couple of Aa19 also adds climate mitigation and doing good for the community as important.

In summary, the Aarhus pilot interviews on UC6 indicate that the app notifications can have some impact on the routines of household members (Aa19 and Aa16); in particular by being a daily "reminder" of options for time-shifting consumption. Also, the interview with Aa19 supports the original idea behind issuing the notifications in the early evening; the assumption was that by sending notifications around the time of dinner, this would remind people of the option of postponing the start of the dishwasher to the next day. Something that the older couple of Aa19 reports having done on several occasions. Furthermore, the interviewees accentuate that financial gains would be an important motive for engaging in demand response actions, which at the same time might be an important part of the explanation of the interviewed households' limited engagement in time-shifting. Finally, the interviews indicate that households with young children living home might feel less time flexible than empty nesters like the older couple in Aa19.

Finally, as an overall conclusion across the two sites and use cases, the following concluding observations can be made: The interviews demonstrate that it *is* possible for people to time-shift consumption, as is clearly demonstrated by the Aran Islands interviews and, to some extent, by the Aarhus interviews. However, the main driver behind the reported demand response actions is if the household owns a PV panel, and therefore find it financially attractive to time-shift consumption. The RESPOND app notifications play a less important role as a driver, even though the notifications seem to have spurred few changes in practices, especially in the Aarhus case (although we must be careful with the conclusions due to the limited number of interviewed Aarhus households). This might indicate that app notifications have the highest impact in households who do not have established practices for time-shifting consumption (like in the case of most of the interviewed Aran Islands households). The Aarhus interviews further indicate that having included economic rewards for the individual households would have incentivized more demand response actions.

3.3 UC4 – MOTIVATE HOUSEHOLDS TO PEAK-SHAVE CONSUMPTION DURING GRID PEAKS BY USE OF MOBILE APP NOTIFICATIONS (ARAN)

In UC4 focused on peak-shaving actions in the Aran Islands households. In total, four notifications were manually sent to the pilot households during June and July 2020. These were sent on Tuesdays or Thursdays on days without other notifications related to UC2. The notifications recommended the households to reduce consumption between 5 and 6 pm. The notifications were issued 4 pm.

Of the six interviewees, three recalled having seen the notifications recommending turning off appliances during peak hours. However, none of these three households did any peak-shaving actions. Various reasons were offered for this: The interviewee of household AR01 said that even though turning of appliances "did cross my mind", he did not follow the recommendations because when he got the notifications, he was usually doing something else which he did not want to be distracted from. The interviewee of household A03 did not pay much attention to the notifications, because he was typically out the home during the peak hours. Finally, the interviewee of household AR04 explained that she already tried to use her appliances during the midday hours

when the PV panels are generating. Therefore, she did not feel that it was possible for her to reduce her electricity consumption during the peak hours.

The interviews indicate that the engagement of the Aran households in UC4 actions were negligible or non-existing. The text of the UC4 notifications was: "Electricity consumption of Ireland peaks within the next few hours, which means higher CO_2 emissions. Turn off some off your appliances between hh:mm and hh:mm – and help us with saving the climate." The message was sent in both English and Irish. It does not appear as the interviewed households did find the notifications motivating for changing their energy consumption. It might be speculated, though, whether offering some kind of financial reward for reducing electricity consumption during peak hours might have had a positive influence on the households' engagement in peak-shaving efforts.

3.4 UC5 – LOAD-SHIFTING DISTRICT HEATING BY CENTRAL (REMOTE) CONTROL OF RADIATOR THERMOSTATS (AARHUS)

3.4.1 QUESTIONNAIRE (SURVEY)

In the following, the main results of the questionnaire survey are summarised. The answers and comments from all participants, all weeks and all days are presented in Annex 11. To avoid translation issues, the comments from the occupants are not translated, but the recurring comments are included in the evaluation as a supplement to the answers of the specific questions.

The survey was carried out by sending an email to all identified adults in the ten dwellings, with a link to the questionnaire using an online survey system (SurveyXact, see www.surveyxact.com). A total of 20 adults were identified, and they received the mail for the first 6 test weeks. As one person fell from 19 persons got the email for the last 4 test weeks. During the ten test weeks the questionnaire was therefore distributed 196 times (6x20+4x19), and answered 149 times, corresponding to a response rate of 76 %.

The respondents constituted 55% (11 out of 20) women. Of the 20 respondents, 1 were under 18 years old, 6 between 30 and 49 years old, 9 between 50 and 70 years old and 4 were more than 70 years old. There were two adults in all apartments and between zero and three children. All tenants have lived in their apartment for a year or longer.

The respondents were relatively much at home partly due to the age distribution and partly due to the Covid-19 situation (test weeks 6-10). There were only slightly differences between days on when and how much they were home. Respondents were on average at home 89%, 55%, 85% and 88% during the time intervals morning from 6 am to 10 am, noon/afternoon from 10 am to 4 pm, evening 4 am to 10 pm and night 10 pm to 6 am, respectively.

Including all assessments during the ten test weeks shows an overall result, that 76% and 24% of the assessments express satisfaction or dissatisfaction with the temperature conditions in the dwellings, respectively. For comparison, they were asked (retrospectively) about their satisfaction during winter with the temperature conditions before the new thermostats were installed. They were identical satisfied before they got the new thermostats. The comments from the occupants

related to problems with too low temperature revealed problems with cold radiators, difficult to control temperature and varying temperature in different rooms and over time.

About a quarter (23%) of the occupants' assessments, indicate some kind of problem with the thermostats. According to the comments, the main problems are related to slow thermostats, too large fluctuations (hot and cold), and thermostats that work more like on/off buttons. As one occupant expressed it: "All radiators have their completely own life".

When the occupants were asked if they experience problems with too low temperature during the ten test weeks, as many as 37% had this problem. This indicate a general problem with too low temperature in the dwellings, see figure 2. Only few occupants experienced problems with too high temperature or draught. Therefore, focus will be on low temperatures in the following analysis.

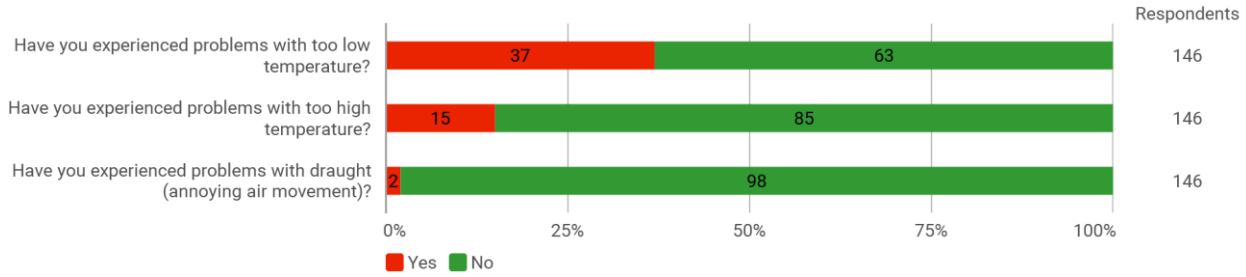


FIGURE 2: THE FREQUENCY OF OCCUPANTS THAT EXPERIENCED PROBLEMS WITH TOO LOW TEMPERATURE, TOO HIGH TEMPERATURE AND DRAUGHT DURING ALL TEN TEST WEEKS.

Because only around half of the DR actions were successful, see above and Annex 2, irrelevant data, i.e. responses from dwellings Aarhus 2, 11 and 15, had to be sorted out of the full data set, and are left out in the following analysis. Figure 3 shows that just over half of the occupants have experienced problems with too low temperature during the four test weeks with no DR actions (baseline) whereas 37% experienced problems with too low temperature during the six test weeks with DR actions.

Figure 4 shows that the highest frequency of occupants experiencing too low temperature is in the morning in the time interval when the DR actions took place. This indicates that the DR actions of switching off the heat occupants leads to some increased cold discomfort. The discomfort is similar in the different rooms, with the exception of the bedroom where only one person (5%) experience problem with low temperature.

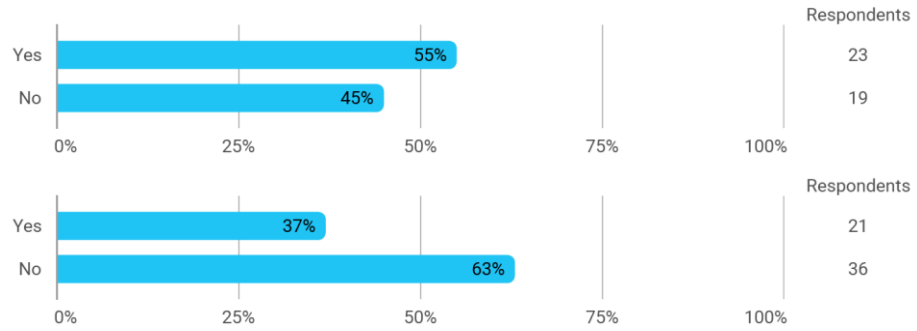


FIGURE 3: THE FREQUENCY OF RESPONSES WITH REGARD TO OCCUPANTS' ANSWER TO THE QUESTION: HAVE YOU EXPERIENCED PROBLEMS WITH TOO LOW TEMPERATURE? (TOP: BASELINE: TEST WEEKS 1,2,9,10 AND BOTTOM WEEKS WITH DR ACTIONS: TEST WEEKS 2,4,5,6,7,8).

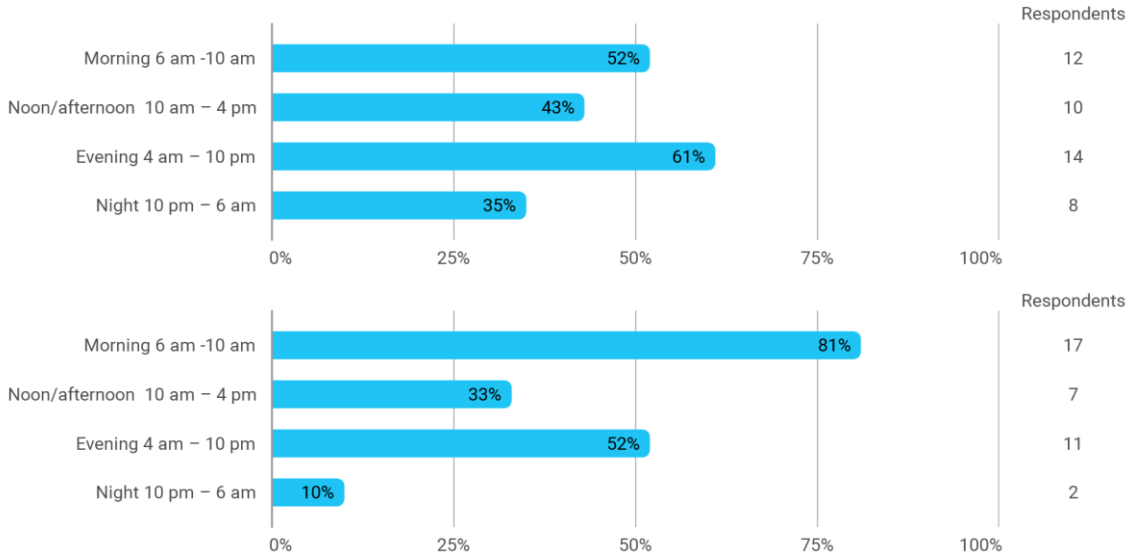


FIGURE 4: THE FREQUENCY OF RESPONSES WITH REGARD TO OCCUPANTS' ANSWER TO THE QUESTION: WHAT TIME OF THE DAY DID YOU EXPERIENCE PROBLEMS WITH TOO LOW TEMPERATURE? (TOP: BASELINE: TEST WEEKS 1,2,9,10 AND BOTTOM WEEKS WITH DR ACTIONS: TEST WEEKS 2,4,5,6,7,8).

3.4.2 INTERVIEWS

Interviews were carried out with five of the ten households, who took part in the heat DR trial in Aarhus. Four of the interviews were carried out in the beginning of April 2020, while the fifth interview were carried out on the 23rd of April 2020. Interviewees were selected to ensure diversity in the sample regarding age and family situation (children living home or not). All interviews were carried out after the end of the DR actions, which ended on the 29th of March 2020. As described earlier (section 2.2.1 and Table 1), closer inspection of the measured data showed some difficulties (anomalies) with how the trial performed in several homes. Unfortunately, this was not known at the time we selected and recruited the interviewees for the qualitative study. It turned out that technical equipment of one of the

interviewed households (Aa02) did not work throughout the entire trial. Thus, we will not draw much on this interview in the following analysis. For the remaining households, the planned DR protocol was performed in part for three households (Aa01, Aa04 and Aa06) and in full for one household (Aa05).

In the following, we will first analyse the interviewee responses to the interview guide questions about how they have experienced the indoor environment and temperature during the weeks of the trial. This includes a discussion of what the interviewee means when they tell about experiences of feeling cold in order to better understand how the DR protocol and trial context might have influenced these experiences. Second, we will explore the interviewees' perceived level of control over the indoor environment of their homes during the trial. Third, and finally, we will present results relating to the interviewees attitudes with regard to participate in future district heat DR schemes, and under which conditions they would be willing to participate in such schemes.

EXPERIENCE OF INDOOR ENVIRONMENT DURING TRIAL

Due to the Covid-19 restrictions at the time of the trial, the interviewees report that they have been more at home than usual from mid-March and through to the time of the interviews. Also, none of the interviewees have been away for longer vacations or similar during the first period of the trial and up to the time of the introduction of the Covid-19 restrictions. Below, we summarize the experiences of the individual households (except Aa02, where the trial did not work as planned) before we make overall observations across the interviews regarding the experienced indoor environment during the trial.

Household Aa01

This household consists of a couple in their 60ies. They tell that they prefer a room temperature of about 20 degrees Celsius. The first floor of the apartment is not normally heated except for the bathroom, which they like to be warm. Also, they turn on the heat in the bedrooms on first floor if they have visitors who stay over for the night. Also, they have not had the heat turned on in the kitchen during the trial period because it has been a warm winter.

They have had a few experiences of feeling too cold during the trial period. However, they can not see a certain pattern in these experiences. Some of their experiences of feeling cold does not fit in with the RESPOND heat DR protocol; e.g., they have on some occasions experienced the bathroom on first floor to be cold (even though this bathroom is excluded from the DR action of switching off the heat in the morning). However, they do also report experiences of cold that seem to fit with the DR heat trial. The most obvious example relates to Test week 7, where they on two mornings experienced it to be cold in the bathroom on the ground floor and in their bedroom in the basement. The heating of both rooms is part of the DR heat trial, and in Test week 7 the heat was turned off from 6-9 am. However, they only experienced this twice and not during the other days of Test week 7 or 8. Overall, they feel that the temperature in the home has been lower than they would have preferred.

The couple has almost not touched the new thermostats after they were installed. They had the impression that it was important not to change the set-point temperatures in order to not interrupt the experiment. This was not the original intention of the trial, and their caution with regard to adjusting the thermostats might have contributed to their overall experience of the temperature being too low. Another thing is that their grandchildren, who visits them regularly, find it exciting to tamper with the

thermostats because of their displays (similar experiences also reported by household 05). This might be the reason for some of the occasions with low temperatures, particularly in the bathrooms.

Another interesting observation is that in the couple's stories about the occasions of feeling cold, they typically explain that they have touched the radiators and felt that they are cold. These stories of tactile experiences of cold radiator surfaces is something that is also mentioned in other interviews (Household Aa04 and Aa06). In some stories, it seems as if the residents first touch the radiators and, if they are cold, this seems to strengthen the overall experience of coolness.

Household Aa04

This household consists of a woman in her 50ies (the interviewee) who lives together with her teenage son. The interviewee tells that it is important for her to feel comfortable, and she does not like to feel cold or to warm. She describes her son as a "freezing stick" who likes to have it hot in his bedroom, typically 26-28 degrees Celsius. The interviewee reports that she has had experiences of feeling both too cold and too warm during the trial period. On several mornings, she has experienced it to be cold in the morning when she came down from the bedroom to the living room. Also, she has experienced the living room to be cold in the evening. She has a sofa right next to one of the radiators in the living room, and she has noticed that the radiator is sometime cold. If the radiator is cold, she feels it is cold in room. Similarly, it was cold in the basement during a period (down to 16 degrees). Then she turned up the heat. It is important that the rooms are not too cold, as there is a problem with high humidity in the dwelling. Also, she has experienced the living room to be too warm one morning. Overall, she has experienced the temperature in the apartment to be less stable during the trial period than in a normal winter – and she has more often adjusted the thermostats than she would do normally. She suspects the external remote control of the thermostats to be the reason for this. However, when it comes to at what time of the day she has had experiences of feeling cold, there is no clear pattern as these experiences have been in the morning as well as at other times of the day.

Household Aa05

This household consists of a couple in their 40ies and two young children. The male partner (the interviewee) tells that he prefers a "homogenous" temperature in the home. The temperature should not variate too much. He finds it inconvenient if he needs to change clothing due to variations in the temperature. It is his experience that they have a slightly higher temperature than most others, typically about 22-23 degrees Celsius. He thinks that the high temperature is "something we have become accustomed to" – it is nice to be indoor without the need to wear a long-sleeved sweater. Compared to previous winters, the interviewee has experienced a bigger need for adjusting the thermostat set-points regularly to achieve a comfortable indoor temperature. Some of this might be related to the couples son (6 years old), who has found it exciting to touch the thermostats because they light up in their displays when the set-point temperature is changed. They have had experiences of too high temperatures (e.g. 25-26 degrees in the parents' bedroom when they go to bed) and too cold (e.g. in the bedroom of their son in the evening). Sometimes the thermostat setpoint has been 16 degrees in the evening – and sometimes in the morning (several thermostats). And as the bedroom on first floor is not tight (draft), this makes the room too cold. They have had similar problems in the rest of the apartment in the morning, except for the bathroom on first floor (not included in heat DR trial). The troubles with the low temperature setpoints have been periodical – and especially in the first weeks after the installation of the thermostats, i.e. *before* the start of the trial, they had many problems because the thermostats appeared

to have "their own life". All in all, there is no clear pattern in the experiences of the rooms being too cold or warm with regard to time of the day, which indicates that these experiences have less to do with the DR trial than with other issues such as unpredictable thermostats or the son tampering with the setpoint temperature. There are *some* cases that could reflect the DR protocol; e.g. when they have experienced cold temperatures in the morning and noticed that the setpoint of the thermostats was 16 degrees Celsius. But as they have also experienced this at other times of the day, it is not evident that this is specifically related to the DR trial.

Household Aa06

This household consists of a retired couple. During the trial period, they have had experiences of the room temperatures being both too high and too low. However, these experiences have typically occurred during the afternoon and evening hours, while the couple cannot remember that is has been to cold or warm in the morning. It is mainly in the living room that they, and in particular the wife, have experienced uncomfortable temperatures. The wife explains that during afternoons with sunshine, the living room can become particular warm, and it is her experience that the radiator is slow in turning down the heating. In the evenings, it is sometimes the other way around; it feels cold because the thermostats are not turning on the radiators in the living room. The wife suspects that the new thermostats are the source of these problems. In the evenings, she sits in the sofa, which is placed right next to the radiator, and she can feel if the radiator is cold. She explains that if she feels cold, she touches the radiator, and if it is cold, she puts on an extra sweater. She does not change the thermostat setpoint, because she knows from previous experience that the radiators will start heating again later in the evening. The husband thinks that to some degree, they might have become more observant than usual with regard to problems of feeling too cold or warm because of the new thermostats. The change – and RESPOND trial – might have increased their sensitivity towards negative experiences and problems of heating. Overall, there is no indication in the interview that the experiences of too cold/hot temperatures are related to the DR protocol; rather, the experiences seem to be related to the change of thermostats that are working differently from the old ones the couple was used to before.

Overall observations

Overall, the interviewed households appear to have had more experiences of feeling too cold or warm during the DR trial period than compared to previous winters. However, these experiences seem more related to the new thermostats installed, and their performance, rather than the DR protocol of the RESPOND trial. In only a few cases, the interviewees' stories are about uncomfortable temperatures that coincides with the morning setback of the heat. The observation that most of the negative experiences might be related to the technical performance of the new thermostats, and not the trial as such, is corroborated by the interview with household Aa02. This family also told about experiences of feeling cold, including in mornings, and observations of thermostat setpoints of 16 degrees Celsius. This, despite the fact that the later analysis of the measured data for this household demonstrated that the DR protocol and trial had failed for this household. The fact that similar stories are told by a household, who have not experienced temperature setbacks in the morning, as the stories of the households, who *have* experienced such setbacks, supports the conclusion that most of the negative experiences reported by the households are related to the performance of the thermostats (and not the DR trial as such). On basis of the interviews, it is concluded that for the interviewed families, the RESPOND DR trial seems to have had a limited impact on the experience of the household members of the indoor environment and

temperatures. In only very few cases, participants might have had experiences of feeling cold (or warm) related to the trial (Aa01 and Aa05).

PERCEIVED LEVEL OF CONTROL OF TEMPERATURE IN HOME

Here, we will first briefly present the interviewees experiences related to the new thermostats that they had installed prior to heat DR trial. Second, we will make some observations related to the interviewees perceived level of control over the temperature of their home during the trial.

As already indicated by the previous summaries of the interviewees experiences of the heat in their home during the UC5 trial, the interviewed in general felt less in control of the new thermostats. In particular two type of stories were recurring across the interviews: First of all, the interviewees told about many troubles with the thermostats in the first weeks after they had been installed. The thermostats had "their own life" and the room temperatures were going up and down without following any predictable pattern. The RESPOND team later discovered that the reason for this unpredictable control pattern was that within the first week after being installed, the thermostats follow an algorithm that calibrates them in relation to the thermal characteristics of the dwelling. Second, most interviewees found it difficult to control the radiator heating, and thereby the room temperature. They experienced the thermostats as being more "sensitive" to setpoint changes than their previous (analogue) thermostats. For example, the interviewee of household Aa04 tells that the temperature in a room can become very high if the thermostat is not correctly adjusted. Several interviewees experience that the thermostats tend to either open fully up for the water flow or turning this completely off, leaving the radiator either very hot or cold. This evidently annoys most interviewees, who seem to prefer the control performance of their former (analogue) thermostats, which seem to have operated more within the middle interval between completely open or completely closed. All in all, the interviewees did not in general like the performance of their new thermostats with regard to controlling the indoor temperature. However, some liked the display that shows the temperature setpoint and the design (aesthetics) of the thermostats.

The dissatisfaction with the new thermostats is important to have in mind when interpreting the interviewees responses about how they perceive the level of control they have had on the indoor temperature throughout the trial. The "sensitiveness" of the thermostats' control performance might be an important explanation for why four of the five interviewed households had a feeling of losing some of their control with the indoor temperature during the trial. The fifth household (Aa06) did not feel a loss of control in general, except when the sun was shining in the afternoon which resulted in high temperature in the afternoon and, later, low temperatures in the evening.

Even if the experience of loss of control only to a limited extent relates to the heat DR trial, one of the interviews (Aa01) provides interesting perspectives on how the experience of level of control can be highly context dependent. The couple of Household Aa01 had, like most other interviewees, experienced a loss of control. But during the interview, the husband made the reflection that their experience of control loss might partly be explained by their understanding that they should refrain from changing the setpoint temperature during the trial (in order to not interrupt the experiment). So instead of adjusting the temperature to their preference when needed, they had typically accepted the uncomfortable temperatures. "We have probably been to cautious", he said. Furthermore, another interesting

perspective came up later in the interview when the interviewers had given a brief description of the idea behind the heat DR trial and the DR control scheme for the thermostats (temperature setbacks, peak-shaving etc.). The wife's immediate reaction was that the idea behind the temperature control made good sense, and this seemed to make a big difference for her experience of the temperature variations they had experienced during the trial: "Surely, that makes really sense to me, right – because I've been tired of it being cold when you get up there [to the bathroom?] – and that's because I'm thinking 'ah, will the heat return or what happens?' If I just know that this is how it is [the underlying control scheme] – when I can make precautionary measures, then I can easily accept it." The quote indicates that knowing the plan and intentions behind a DR trial, like the RESPOND heat DR trial, can make an important difference to how temperature variations will be experienced. This raises the question whether heating DR solutions should provide sufficient information to the participants of the underlying aim and control plan for the DR program in order to promote the acceptance of the occupants.

ATTITUDES TOWARDS PARTICIPATING IN DISTRICT HEATING DR SCHEMES

The interviews with the households concluded with questions asking about their willingness to participate in future demand response programmes for district heating peak-shaving (if such programmes were to be offered to the district heating customers). This part of the interview was introduced with a short description of the idea behind using DR control of heating to peak-shaving morning peaks. The introduction included pointing out possible benefits such as customers saving money or less need for upgrading heat distribution systems in cities (involving less inconvenience due to less need for digging up roads to put down new or replacing old district heating pipes).

The interviewees were overall positive about the idea of being part of future heat DR schemes. One of the most positive reactions came from the couple of Aa01. When asked what incentives they would like to accept a heating DR scheme, the wife answers that "it is simply a good idea – and if the alternative is to dig up all roads in the neighbourhood to put down new pipes … it would be nice to avoid that – and if you can do it [avoid it] in this way by making a collective deal [i.e. that the residents in the area agree among each other to accept DR control], then that would be super." To this couple, price would not be decisive for their acceptance of such a scheme. The benefit from avoiding upgrading the pipelines (and the associated inconvenience) would in itself be an important motivation.

In addition to avoiding the inconvenience related to upgrading pipelines, which seems to be a shared concern by several interviewees, also the idea of saving some money appears to be an important incentive. Though, it is difficult for the interviewees to give estimations of how much they should save to accept a DR programme. Finally, saving the environment is mentioned in one interview (Aa06) as another benefit that could motivate the interviewed couple to accept DR control.

Several interviewees comment that it is important that the DR scheme would not involve the risk of feeling too cold. It seems like most households would accept a temperature drop (during setbacks) of 1-2 degrees Celsius, but not more than that in general. And two interviewees would also prefer a solution where certain rooms could be exempted from the DR scheme (i.e. kitchen and bathroom). Thus, the interviews show, on one hand, an overall positive reception of the idea of heat DR (peak-shaving in morning hours), but at the same time, this acceptance is conditioned by a wish of the interviewees to remain some control

of a) how much the temperature can drop during setbacks and b) an interest in a scheme that can offer room differentiated control.

3.5 UC7 – PRICE-BASED DR FOR ELECTRICITY CONSUMPTION – COMBINING "HAPPY HOURS" WITH APP NOTIFICATIONS TO HOUSEHOLDS (MADRID)

The aim of use case UC7 was to incentivize the Madrid pilot households to time-shift electricity consumption away from hours with peak consumption though offering hours with free electricity (no charge – "happy hours") outside the peak hours. As described in section 2.2.2, the UC7 consisted of four different periods with different happy hours schemes. In order to evaluate the user engagement, two rounds of interviews were carried out. The first was done by the end of May, collecting information about the residents' experiences with the three first periods. On basis of these interviews, changes were made to the happy hour scheme, and a second round of interviews was carried out in the end of July to evaluate the residents' experiences with this final scheme. In the following, the insights from these two interview rounds are reported and analysed.

At the **first round of interviews**, only two of the eight interviewed households report time-shifting of electricity consumption (M00 and M12). The interviewee of household M00 tells that the whole family is motivated to shift consumption to the "free hours" of electricity (at the time of the interviews, this was 3-4 pm and 10-11 pm). Especially the children were motivated. He told that they were educated to do so and take it as a game. It is mainly clothes washing and dishwashing they time-shift to free hours, while they try to lower consumption from other electrical appliances during the other hours of the day. This household is in many ways different from the other interviewed households, as the efforts in time-shifting consumption appears to be an activity that all family members are engaged in. In the interview, the interviewee of M00 comments that the motivation for time-shifting was highest in the first two weeks after the take-off of the free hours. Since then, their engagement has decreased somewhat. He thinks regular notifications would facilitate to keep the high motivational level (e.g. receiving notification every day around 6 am and just before the happy hours begin). The other household performing time-shifting of their consumption is household M12. Here, the interviewee tells that he and his wife is highly motivated to time-shift consumption and that they run devices such as the washing machine, dishwasher and air conditioner in hours with free electricity. Even though only two households reported to perform demand response actions in the first round of interviews, these two families appear highly engaged.

Another interesting observation from the first round of interviews is that the majority of interviewees (seven out of eight) only remembered the price schedule communicated at the very beginning of the UC7 trial. This was the 14 hours of free energy (from 10 pm to 12 am during November through March and from 11 pm to 1 pm in April). These hours were originally communicated to the residents via a fridge sticker that had been distributed to the households. Several interviewees referred to this sticker and they believed this was still the active scheme, even though it had been changed to two hours a day (3-4 pm and 10-11 pm) about a month before the interviews were carried out. The new price schedule had been communicated to the residents via the app (notifications) and SMS text messages, but – apparently – except for one interviewee, none had noticed the change and the new hours (e.g., one interviewee

remembered having seen the app notification, but did not notice the change in hours). Some interviewees even reacted negatively to the information about the new price scheme when they were told about it in the interview setting. Most critical was the interviewee of household M10, he said that he had got used to the initial 14 hours of happy hours and that he did not like the change, which he felt was unfair. Two important analytical observations can be made from this: First, this indicates that the first communicated message tends to be what people remember. The implication of this is that extra care must be put into how a new DR scheme is communicated to customers and to avoid too frequent changes in such schemes, as the risk is that later changes is not recognized by the customers, who have got used to the initial scheme. Second, in the Madrid case, the fridge sticker appears to have been a strong communication tool – and apparently much stronger than the following app notifications and SMS messages about the change in price scheme. However, it has to be noted, that a reason for limited awareness of the new price scheme might be that at the time of the first round of interviews, several interviewees appeared to have had problems with downloading the mobile app. Thus, it is not certain they had received the app notifications about the new price scheme.

The first round of interviews also provided other important insights about the households' engagement in UC7. In particular two types of observations, with implications for the design of price-based DR schemes, were made by the interviewees:

- **Channel of communication:** The interviewees were asked about their preferred channel of communication about the price scheme. While two preferred the RESPOND app (M00 and M01), most would prefer to receive notifications via WhatsApp (M02, M03, M06 and M10) or by SMS (M03, M04 and M12). One suggested receiving messages via email (M06). The most typical reason provided for preferred channel was that they already used this frequently and therefore were familiar with it.
- **Length of "happy hours":** Another important insight from the Madrid interviews relates to the length of happy hours – and how this affects the electricity consumers' practical opportunities to time-shift consumption. Several interviewees commented that the 1-hour long happy hours (3-4 pm and 10-11 pm, respectively) were too short to run a washing machine or dishwasher programme cycle. Typically, these programmes take longer than just one hour. And as these are the typical activities that the residents would consider shifting to the peak-hours, this made it less attractive for them to adapt daily routines to the price scheme. Thus, interviewees suggested to extend the happy hours, e.g. to two hours. This recommendation was subsequently adopted in a revised version of the UC7; from June 2020 the pilot households were offered 2 times 2 hours with electricity free of charge (3-5 pm and 10-12 pm).

The **second round of interviews** were carried out at the end of July 2020, and it included questions about how the households had reacted to new 2 times 2 happy hours price schedule, which had been introduced by the beginning of June 2020. Compared to the first round of interviews, the interviewees reported much more extensive activity with regard to time-shifting electricity consumption. Of the eight interviewed households, seven interviewees said that they did demand response actions (see table 3).

TABLE 3: DEMAND RESPONSE ACTIONS OF THE MADRID HOUSEHOLDS

	Washing machine	Dishwashing	Air-conditioner	Dinner (cooking)	Other
M00	X	X			X
M01	X	X		X	
M02	X	X	X		
M03	X	X			
M04					
M06	X		X		
M10		X			
M12	X		X		

The interviews show that clothes washing and dishwashing were the activities that the households did time-shift most often. However, several also time-shifted air-conditioning, while one interviewee even reported to change the timing of dinner. The interviewee of this household said that they are moving the dinners to 10-12 pm during the summer, which is fairly easy to do during the summer season.

The answers by the interviewees indicate that the change in the length of happy hours from 1 hour to 2 hours made it easier for the households to adjust their daily activities to the happy hours. The interviews also indicate that – over time – the time-shifting becomes a new habit that the residents do not need to think much about in their daily life. For instance, the interviewee of M00 tells that the entire family, including children, is engaged in time-shifting activities, and that they do not find it very hard, because moving consumption to the happy hours is a routine that the family have integrated in their daily life. In addition, the children take part in it as a kind of game.

The timing of the happy hours (3-5 pm and 10-12 pm) appears to fit quite well with the daily rhythms of the families, although a few comments that it sometimes involves problems for them. Thus, the interviewee of M06 said that the problems they find to shift consumption are related to work timetables and busy agendas. If the family is staying at home, they do not have any problems to move consumption, but often they are not at home during the happy hours. Here, however, it should be commented that due to Covid-19 restrictions, many of households interviewed have stayed more at home than they usually do. This might have affected their answers to the questions about time-shifting consumption; it might have been easier for them during this specific period than it would have been normally when they are more out of the home.

All in all, the UC7 with 2 times 2 happy hours a day appears to have been successful in promoting time-shifting among the Madrid pilot households, at least measured by the participants' self-reported actions.

The interviewees were also asked about their attitude towards allowing automated demand response control of appliances, e.g. allowing automated control of the start of dishwashers and washing machines. The answers demonstrate a quite positive attitude to this. Out of the eight interviewed, five interviewees

were positive about the idea. Several mentioned that they would be willing to accept automated control if it was to the benefit of society (the common good) or the environment, though several also would like to save some money from doing this. One interviewee (M01) would prefer if she was notified in advance before automated actions were performed.

Three interviewees were either negative or hesitant about the idea of accepting automated control. For instance, the interviewee of M02 was hesitant with regard to which appliances he would allow automated control of, even though he thinks he would not mind automated actions with dishwashers and air-conditioners (allowing some temperature reduction). Another interviewee (M04) refused the idea, because she cannot manage to use the app and feels uncomfortable about this type of services. She is also the only household, who did not report doing any time-shifting actions. She lives by herself and has a minimal energy consumption because of this. For instance, she runs only four washing machines and dishwashes per month. Therefore, she thinks that her level of consumption is too little for time-shifting consumption. A similar reason (low consumption) was provided by the interviewee of M10 for not being interested in taking part in automated control actions (he also lives by himself).

3.6 UC8 – MAXIMISE EXPLOITATION OF DHW RE RESOURCES BY SENDING APP NOTIFICATIONS TO HOUSEHOLDS ABOUT WHEN IT IS BEST TO CONSUME DHW (MADRID)

In this use case, it was initially planned to use the RESPOND app to notify users when to consume DHW in order to optimize the solar thermal production from the solar thermal panels installed in the Madrid pilot site. Due to technical issues, the original plan was not carried out. Instead, the pilot households were asked about the hypothetical scenario of receiving such notifications via the app, SMS or telephone call. An example of such a recommendation could be: “We recommend you to use the domestic hot water from 12 am to 6 pm to take advantage of the solar thermal generation”.

If notifications were sent to recommend about when to use the domestic hot water (DHW) to take advantage of the solar thermal generation, in general, the interviewed residents would not mind to receive those alerts, but most of them would find it difficult to time shift showers (the type of DHW consumption that most interviewees identified as potential for time-shifting). No other type of DHW consumption that could be time shifted was identified by the interviewees. Only families with children said that maybe the children’s showers could be time shifted. Adults have strict routines related to showers, usually during the mornings or nights, which make it difficult for them to move showers in time.

When asked if the families had already tried to time-shift their consumption (since the solar thermal panels were installed), none of the interviewed residents reported having done such time-shifting. As described earlier, in general all of them find difficulties in time-shifting showers or any other DHW consumption. However, three interviewees were positive towards the idea of shifting DHW consumption. The families with middle age adults with children seem to be more likely to try to change some habits (e.g. children showers).

The interviewees were also asked if they had noticed any reductions in their bills due to the installation of the solar thermal panels. In general, from the answers provided, the interviewed residents have not

noticed any reduction in the bills. Reasons for this are that they did not check the bill or it is difficult to say as different concepts are charged together in the bill for the community expenses. Also, the savings are distributed among many neighbours (making the individual saving relatively little).

The interviewees were also asked if they would be willing to maintain the installation of solar thermal panels, even if the bill reduction were very low, in order to contribute to improve the environment. The answers showed some diversity, though more than half of the interviewees would be willing to maintain the installation even if the financial savings would be small.

In conclusion, the interviews show that people experience little potential for time-shifting their DHW consumption in order to optimize the use of local solar thermal power. The only exceptions from this tend to be families with young children, who might consider time-shifting the bathing/showering of the children. While the demand response potential for DHW appears very little, the interviewees were overall positive towards the installation of solar thermal panels to the benefit of the environment, even if the financial gains from this might be small.

4. CONCLUSIONS AND LESSONS LEARNT

This section summarizes the main findings and conclusions from the user engagement assessment of the RESPOND project. First, an overall observation about learning from trials is made. Then follows separate conclusions for the individual use cases, including a number of lessons learnt.

4.1 OVERALL OBSERVATION – LEARNING FROM TRIALS

The user engagement study has demonstrated that – despite many specific challenges related to the users' involvement and interaction with the RESPOND app and DR solutions – the pilot households at all three sites have been highly dedicated and engaged pilot participants. With almost no exceptions, the recruited families have had a positive attitude to the project and – in several cases – been patient with technical challenges that have occurred throughout the development and setting up of specific use cases. Thus, the RESPOND project is grateful to all participating households for their valuable contributions and help.

This leads to another observation that should be kept in mind when interpreting the results and conclusions regarding the user engagement of this project: Households who volunteer to take part in pilots and demonstrations (like this project) might tend to be more engaged and positive towards trying out new things than can be expected from households or customers in general. This is *not* the same as saying that the findings from the RESPOND use cases cannot provide important insights into barriers and motivators for peoples engagement in future demand response programmes. On the contrary, the stories and everyday dynamics reported in the interviews are likely to be similar to most other households – especially as we have aimed for a relatively diverse group of participants when it comes to age and family composition. However, in some cases the RESPOND pilot households might have been more interested in energy-related themes from the outset or the trial-context in itself can have kept some households more engaged (and for a longer time) than could normally be expected from other households/customers. In many ways, this is a premise for demonstrations and trials, but it should be kept in mind when interpreting the results.

4.2 USE CASE SPECIFIC CONCLUSIONS AND LESSONS LEARNT

UC1 MOBILE APP PROVIDING ENERGY DATA FEEDBACK TO HOUSEHOLDS (ALL SITES)

The interviews show that the RESPOND app was only downloaded by one person per household – most often the male adult of the household. In households with more than one person, the fact that only one person typically downloads and uses the app might be a limiting factor for the success and impact of such apps, since the energy consumption depends on all household members' activities and engagement in the DR actions. Most users of the RESPOND app use the app on weekly or less than a weekly basis. Push messages (notifications) are therefore an important tool for communication to the users. Regarding age, the interviews show that older

people more often than younger people lack the needed skills and competences to download, install and use the RESPOND mobile app. This said, the elderly is a diverse group, which also includes some very active and devoted app users.

With regard to overall satisfaction with the app, several are happy about using the app, but there is also many who find it too difficult to navigate and to understand the provided information (the intelligibility of the app), who find the app to be too slow in loading pages (speed) and who have experienced errors or breakdowns. These problems affect the participants' overall user experience negatively and is also the reasons why some interviewees have given up on using the app.

The most common used features of the RESPOND app were: Comparing consumption with neighbours, monitor one's own energy consumption, air humidity and temperature and local weather forecast. That comparing one's own households' energy consumption with the consumption of neighbours is the most often used feature of the app supports that comparison with others is a lever for engagement in DR and energy saving actions. The interviews also demonstrate how comparing own consumption with others can trigger energy saving actions.

On basis of the above findings and conclusions, the following lessons learned for UC1 can be defined:

- The design of mobile apps should take into consideration that in most cases only one person in a household (typically a male adult) uses the app – and that this person might not be the same person as the household member who performs household activities with highest energy consumption (e.g. clothes washing).
- Age plays a role as older people in general tend to find it more difficult to download and use the app (even though this age group also includes a minority of very active app users). Mobile apps should be designed to be easy to use also by older people.
- It is important that mobile apps are intelligible (easy to navigate), fast (load pages quickly) and reliable (no errors or breakdowns).
- Many households find it interesting to compare their own energy consumption with that of their neighbours, and such comparisons can spur energy saving actions.

UC2 & UC6 Maximise auto-consumption from PV panels by sending mobile app notifications to households about optimal time to consume electricity (Aran & Aarhus)

Two use cases were based on app notifications to the pilot households on Aran Islands (UC2) and in Aarhus (UC6) with recommendations on when it was optimal to consume electricity form local PV panels. The interviews show that it is possible for people to time-shift consumption, which was a widespread practice for the households on Aran Islands (homeowners with own PV panels) and to some extent also in the Aarhus households (tenants of housing association with collectively-owned PV panels). However, the interviews showed that the Aran Islands households were much more actively engaged in demand response actions than the Aarhus households. The primary reason for this is that the Aran Islands households own their PV panels themselves and therefore see a direct financial incentive in time-shifting their consumption. For the households in

Aarhus, the economic benefit from doing DR actions were less evident. Washing machines, dishwashers and tumble dryers (if used) are the appliances that are typically shifted in time.

The app notifications had a limited impact on the actions of the Aran Islands households (primarily because they *already* do DR actions), while the Aarhus interviews indicate that the notifications spurred some changes in the daily practices of these households. If the UC6 in Aarhus had included direct financial incentives to the households for time-shifting electricity consumption, it is likely that the app notifications would have had a larger impact on the practices of the households.

The above findings and conclusions lead to the following lessons learned for UC2 and UC6:

- Individual ownership of PV panels results in a more active engagement in demand response actions than shared ownership as in social housing associations. Thus, to engage tenants in such actions, it is important that financial gains from time-shifting consumption is allocated to the individual tenants.
- App notifications with recommendations on demand response actions can be a helpful tool, especially as a reminder and learning tool for households that have not already established such DR practices.

UC4 Motivate households to peak-shave consumption during grid peaks by use of mobile app notifications (Aran)

In UC4, app notifications were issued to the Aran Islands pilot households with recommendations on reducing their own electricity consumption during grid peak hours. The interviews demonstrated a very limited (or none) action to these notifications. On basis of this, the lessons learned appears to be:

- If app notifications on peak shaving shall have an effect on households' electricity consumption, these must be combined with some kind of incentive for people to make peak-shaving actions, e.g. a financial incentive like high prices during peak hours or a bonus/premium for reducing power consumption.

UC5 Load-shifting district heating by central (remote) control of radiator thermostats (Aarhus)

Questionnaire responses and qualitative interviews performed during and just after the UC5 trial indicate that the morning set-back of heating did increase the frequency of occupants perceiving problems with low temperature in the morning hours. However, the study also shows that thermal discomfort to some extent was related to issues with the technical performance of the new thermostats. Considering this, it is concluded that the UC5 temperature set-back trial did result in a moderate increase in the incidents of feeling cold in the morning.

Another important observation from the study is that the participants' experiences of the thermal indoor environment is dependent on how the DR actions (like those tested in UC5) are framed and communicated to the participants. Thus, the interviews indicate that knowing the plan and intentions behind a DR scheme can make the participants more acceptant to changes of their

indoor temperatures related to DR actions. This acceptance is further supported if households believe that their participation in a DR scheme is part of a shared, collective action – e.g. on a neighbourhood level – and supports societal goals like avoiding the need of upgrading the local district heating pipelines or mitigate climate change. In addition, they also find economic incentives important for their participation. However, it is important to observe that financial incentives are not the only element that can motivate households to take part in schemes of load-shifting district heating; the financial incentive should be combined with other elements that make it meaningful in a wider sense for people to engage in such schemes.

With regard to the design of DR schemes for heating, the interviews – and previously focus groups (deliverable D3.3) – show that occupants prefer to keep control of the temperature level and how much the room temperatures are allowed to drop during DR actions. They also prefer to be able to decide which specific rooms of the home that are included in the DR actions.

Finally, it should be mentioned that carrying out the DR actions of UC5 involved many technical issues and problems, which also to some extent affected the participants and their perception of the thermal indoor environment. In many ways, such challenges are to be expected in innovative trials like this one, but they also show that advanced and decentralized solutions, as the remote control of temperature setback trialled in RESPOND solution, face significant challenges with regard to creating a seamless, integrated and reliable system across thermostats, gateways, central databases etc. These challenges shall be taken into consideration, when designing DR solutions for time shifting heat in dwellings.

The above observations and conclusions can be translated into the following lessons learned from the UC5 trial, which can be valuable for future development of new heat DR schemes:

- The DR concept of time shifting heating in the morning by central (remote) control of radiator thermostats showed to be a usable solution for peak shaving. This despite of occupants experiencing some negative impact on the perceived indoor thermal environment in the morning.
- Before introducing DR schemes with heating setback, it is recommended to establish conditions allowing occupants to adjust the temperature in their dwelling to their preference. This may require an increased heating capacity of the radiator system, better wall insulation and/or new low energy windows.
- Knowing the plan and intentions behind a DR scheme can make the occupants more acceptant to changes in their indoor temperatures related to DR actions – especially if the positive implications for the local neighbourhood or wider society (e.g. environment) is communicated to them.
- Saving money (financial incentives) is a motivational element for households to participate – though, importantly, not the only motivational element.
- The heat DR scheme should be designed in a way that allow occupants to adjust the temperature level to their preference and allow for some freedom to adjust the setback scheme and accepted temperature variations according to their individual needs.
- Heat DR schemes based on control of individual thermostats (radiators) implies a high level of technical complexity, which makes the system vulnerable to technical problems.

This needs to be considered and weighted against more simple and robust DR solutions based on central control.

UC7 Price-based DR for electricity consumption – combining "happy hours" with app notifications to households (Madrid)

The UC7 was, like UC4, also focused on time-shifting electricity consumption away from hours with high electricity demand. But in contrast to the UC4 on Aran Islands, the UC7 in Madrid was based on static Time-of-Use tariffs and included an economic incentive in the shape of reduced electricity price during the off-peak hours ("happy hours"). The UC7 resulted in several interesting observations. First, the interviews showed a quite strong (self-reported) engagement in time-shifting consumption, in particular dishwashing and clothes washing and to some extent also the use of air-conditioning. This might indicate that offering an economic incentive (the "happy hours") play a decisive role in motivating the residents to time-shift consumption. Also, it might be easier for households to adapt their daily practices (e.g. when they do dishes and wash clothes) to static Time-of-Use schemes than to more "dynamic" schemes like the irregular peak-shaving alerts trialled in UC4. Second, the interviews showed widespread resistance towards later introduced changes in the timing and duration of the "happy hours", which shows that it is important to be careful when introducing new pricing schemes – i.e. avoiding changing these too frequently. Third, the interviews gave important information on the minimum duration of "happy hours", as these should last at least two hours in order to make it possible for people to run a full cycle of appliances like dishwashers or washing machines. Finally, there was a relatively widespread interest in automated demand response control of appliances among the interviewed households.

The above findings lead to the following lessons learned for UC7:

- Static Time-of-Use schemes with a significant economic incentive (like "happy hours" of free of charge electricity) motivate households to time-shift consumption away from peak-hours.
- The duration of low-price periods should be – at minimum – two hours in order to make it possible for households to run appliances such as dishwashers, washing machines and tumble dryers, which are the appliances that are in general most often time-shifted.

UC8 Maximise exploitation of DHW RE resources by sending app notifications to households about when it is best to consume DHW (Madrid)

This use case evaluation was based on interviews with Madrid households about a hypothetical scenario of receiving notification via app, SMS or telephone call on when to consume DHW in order to optimize the consumption of locally produced DHW from solar thermal panels installed at the Madrid pilot site. The interviews showed that while the interviewees were positive to the idea of receiving such notifications, they in general saw little potential for time-shifting their DHW consumption in order to optimize the use of local solar thermal energy.

The above finding leads to the following lessons learned for UC8:

- There is a limited potential for making households time-shift their DHW consumption as a way to optimize the utilisation of local solar thermal energy production.

5. REFERENCES

Barbosa Neves, B.; Waycott, J.; Malta, S. (2018). Old and afraid of new communication technologies?: Reconceptualising and contesting the "age-based digital divide." *Journal of Sociology (Melbourne, Vic.)*, *54*(2), 236–248. https://doi.org/10.1177/1440783318766119

Brinkmann, S.; Kvale, S. (2015). *InterViews – Learning the craft of qualitative research interviewing*. Thousand Oaks, California: Sage Publications.

Christensen, T.H.; Friis, F.; Skjølsvold, T.M. (2017). Changing practices of energy consumption: The influence of smart grid solutions in households. *ECEEE 2017 Summer Study on energy efficiency*, Presqu'île de Giens, Hyéres, France.

Deakin, H.; Wakefield, K. (2013). Skype interviewing: reflections of two PhD researchers. *Qualitative Research: QR*, *14*(5), 603–616. https://doi.org/10.1177/1468794113488126

Dobbyn, J.; Thomas, G. (2005). Seeing the light: The impact of microgeneration on the way we use energy. London: The Hub Research Consultants. Download from: http://www.sd-commission.org.uk/publications.php?id=239

Olkkonen, L.; Korjonen-Kuusipuro, K.; Grönberg, L. (2016). Redefining a stakeholder relation: Finnish energy "prosumers" as co-producers. *Environmental Innovation and Social Transitions* 24:57-66.

ANNEX 1: GUIDELINES FOR PREPARING AND CARRYING OUT INTERVIEWS AT PILOT SITES

This document presents the guidelines for the interviews to be carried out at the pilot sites in Spring/summer 2020.

The aim of Task 6.3 is to report on the overall **user engagement and satisfaction** during the RESPOND demonstration activities at the three pilot sites in Denmark, Ireland and Spain. Originally, it was planned to carry out two focus groups at each site with pilot households to provide the basis for a detailed qualitative analysis of user experiences and the users' own **recommendations for possible further improvements**. However, due to the Covid-19 situation and the current restrictions on people's interaction (physical distancing), it has been decided to replace the T6.3 focus groups with individual online or phone qualitative interviews with 5-10 pilot households per site. The interviews will be conducted by the local pilot partners with the use of an interview guide developed on basis of a general guideline (this document!) from AAU. Like for the originally planned focus groups, the aim of the interviews is to collect data on user experiences and satisfaction for the final analysis of this.

In the following, we will first give some instructions on how the pilot partners can prepare the interview guide (i.e. the questions and themes) to be used for the individual household interviews (section 1). Next, we will give some general advice on how to carry out qualitative interviews (section 2). Finally, a time schedule for the work is proposed in order to keep the originally planned deadline or to postpone completion of the task (section 3).

We hope this can be helpful for your preparation and completion of the interviews. As always, please do not hesitate to contact us at AAU if you have questions or need some other kind of help!

1. Preparing the interview guide (IG)

Doing qualitative interviews is different from doing questionnaire surveys, as the questions to be asked are less fixed than in surveys, where all questions are fixed and asked in the same way (and order) to all respondents. In qualitative interviews, the order of questions might change from interview to interview due to individual differences between interviews, and the wording of the questions (how they are asked) are not exactly the same across interviews. Typically, one will phrase questions in a way that suits the interview situation and relates to what the interviewee has said previously. And sometimes you will add new questions during the interviews as a follow-up on things that the interviewee has said that are relevant to the project, but you did not anticipate when preparing the interview questions. In other words, the qualitative interview is more flexible and "organic" than a questionnaire survey.

This said, the qualitative interview still needs to cover the main questions we want the household participants to answer – and we need some degree of consistency across interviews with regard to the questions we ask. This is to ensure that we can make comparisons of answers between interviews and make overall structured summaries and conclusions. For instance, if we only ask about the use of the mobile app in one interview in Aarhus, and not in the other Aarhus interviews, it would be difficult to make any overall conclusions about how the pilot households experienced the mobile app more generally (as the conclusions would be based on a single family).

In order to ensure that we ask relevant questions with a sufficient level of consistency across interviews, a so-called "interview guide" (IG) is developed before carrying out the interviews. The IG includes the main overall

topics of the interviews and provides – for each of the overall topics – some suggestions for questions to be asked (often with some follow-up questions for each of these questions).

Again: In the interview situation (while doing the interview), one might not ask the questions with the exact same words or in the same order as originally planned in the IG. However, the wording will be something similar to what was originally planned.

For inspiration, we have included an English translation of the IG used for the interviews with households taking part in the heat DR trial in Aarhus (see Annex 2). In addition to this, we are currently preparing further Aarhus interviews focusing on the auto-consumption of solar power and the use of the mobile app.

How to prepare the interview guide for your specific cases

The **first step** in preparing the IG is to identify what the interview is going to be about – i.e.: What are the overall research questions you need to answer via the interviews. In the Aarhus heat DR interviews, we identified three overall research questions:

A. In what ways have the informant (and the others in the household) experienced the experiment of controlling heat in the home? Both in general and specifically in relation to thermal indoor climate (temperature and draft)?
    - Differences in perceptions between household residents?
B. How has the informant experienced participating in the RESPOND experiment?
    - This question has a broader focus and also deals with experience with the installation of equipment, non-working technology, uncertainty about the design of the experiment, etc.
C. What thoughts do the informant have about a future scenario of *external* control of the heat in the home?
    - What kind of control is acceptable? Which is not?
    - What can motivate the informant to accept *external* control of the heat? (Economy, environment, doing something for the community ...)

As can be seen from the above, we were in Aarhus interested in collecting information from the residents about a) how they had experienced the heat DR experiment, b) how they had experienced the RESPOND trial in more general terms and c) their thoughts in general about a future scenario of external control of residential heating.

In your cases at Aran Islands and in Madrid, you need to decide what should be the main research questions that your interviews should answer. Obviously, these questions should relate to the use cases you are working with at your pilot site. For instance, at Aran Islands there will probably be research questions related to the households' experiences with peak-shaving (UC4) and maximising auto-consumption (UC2 & UC6), as well as about the experiences with the mobile app (UC1). The latter might be an integrated part of the before-mentioned use cases (?).

When having decided on the overall research questions, the **second step** in preparing the IG is to "translate" the overall questions into specific questions that can be asked during the interviews. For instance, in the Aarhus heat DR interviews, we began the interview part related to research question A by first asking a general question about what is a good thermal indoor climate for the interviewees ("What will it take for you to feel comfortable indoors in relation to heat and temperature?"). This was to understand the interviewees' existing preferences before zooming in on their experiences with the specific DR trial. A bridge from the general question to the more specific questions was made by asking: "Do you find sometimes that the temperature/the heat is not right in your dwelling/a room? What do you do then?" With this question, we changed focus to the interviewees' experiences with "feeling uncomfortable". Then followed a more specific question relating to the DR trial: "How have you experienced the temperature in your apartment since the beginning of February and up to today?" In connection with this question, we had a number of follow-up questions in order to ensure sufficient details in the

interviewees' answers. Several more questions related to research question A followed, but we will not go into detail with these here (see Annex 2 for more).

In addition to the sections of the IG related to your specific research questions, there should also be an **introduction with some general questions** about the household that is needed to understand the context. In the Aarhus heat DR interviews, this section included the interviewee's description of him/herself, the household composition and how a typical weekday looks like for the family. The aim of the latter question was to ensure that we had context-related information that could prove important for interpreting the interviewees' answers about how they had experienced the indoor thermal comfort during the DR trial. For instance, if the household members would typically wake up and leave home very early in the morning, this could be a reason why they might not report any problems with the temperature setback in the morning hours. In other words: If we know the family leaves early in the morning before the temperature setback begins, we cannot use their statements to conclude anything about how the experiment affects people's experiences of the thermal indoor climate. Likewise, on Aran Islands and in Madrid, you might need to think about similar context-related information that will be essential in order to interpret (and validate) the conclusions to be drawn from the interviews – and to include questions about these in the first part of the interview.

With regard to how to set up (design) the IG, you might find the structure of the Aarhus IG (Annex 2) useful with its three columns of Topic (research question), Aim (a slightly more detailed description of the aim of the research question) and Questions (suggested questions to be used during the interview).

A final comment on how to prepare the wordings of interview questions: **Try to make open questions** (typically beginning with *why*, *how*, *what* and *when?*) and avoid priming the answers by "leading questions". Open questions invite the interviewees to give answers that are as close as possible to their immediate experiences and thoughts, while "leading questions" direct their thoughts in a specific direction and might "colour" their answers. Of course, it is not always possible to phrase questions as *why, how etc.* questions (sometimes one needs to ask a specific question), but try to do it as much as possible.

When you have prepared the research questions – and maybe also a first draft of the questions to be asked – you are welcomed to send it to AAU (in English, please 😉) for comments and suggestions. Again, don't hesitate to contact us for help on this.

Recruitment strategy

With regard to who to interview, you should aim for diversity in the sample of interviewed households with regard to their age, life phase (having children living at home or not) and preferably also education/occupation. Diversity in the sample helps avoid recruitment biases (e.g. the bias of only interviewing people with no children living at home, which might otherwise affect their answers with regard to their level of engagement in demand response activities). Consequently, diversity also improves the validity of the results and can help point out differences between different groups of people.

2. Advices on how to carry out interviews

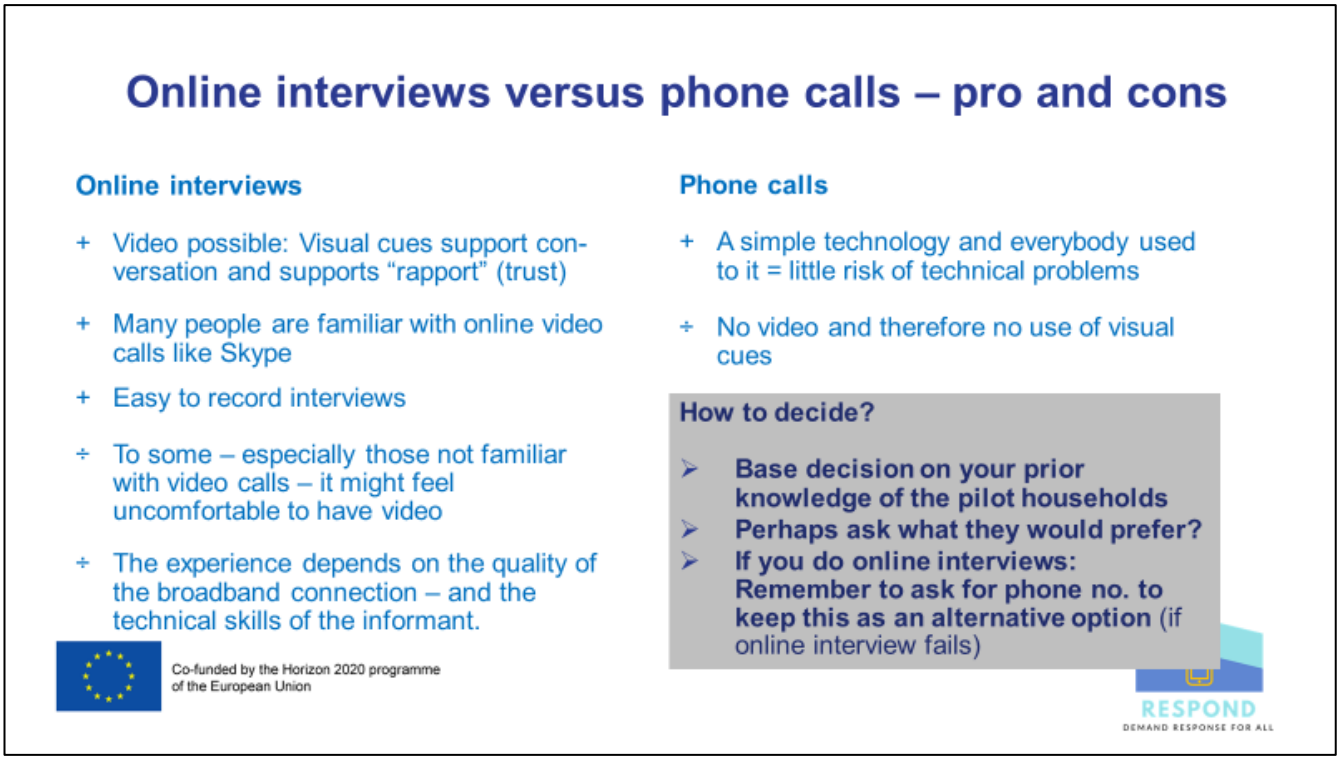
With the IG prepared and ready, time has come to do the interviews. Here are some general advices, which we hope you will find helpful:

- Give the informants time to answer questions – and time to think about their answers. Often, pauses (breaks) are due to the interviewee thinking about your question and what to answer. So, if you rush in with a new question, you might interrupt their thinking and you might never get the answer to your original question.
- Allow yourself time to think about the next question to ask! And be vocal about it. You might simply explain the interviewee that "sorry, I just have to look at my questions to be sure that I remember to ask the things I

have planned to ask". Interviewees will find this completely understandable – and you'll get some time to prepare your next question.

- If informants start talking about something not relevant for the interview, bring them "back on track" in a polite and appreciative way (e.g., *Well, it's really interesting to hear about where you grew up, but I would also very much like to know how you experienced the temperature last week? …*).
- As said several times above: The interview guide is a *guide*, not a straightjacket. You are allowed to change order of questions, if this makes better sense to the informants and in the interview situation – and you can also rephrase questions… Or even add new questions that you had not thought about while preparing the IG, but that turns out to be something important to the interviewees' stories and to your overall research questions.
- If you are two interviewers (as we were in the Danish heat DR interviews), it is important that a) both interviewers are introduced and say "hello" to the interviewee, b) that you explain clearly to the interviewee how you have divided the work between yourselves (in our case, Toke was the "main interviewer" asking the questions, and Henrik would listen and sometimes have "follow-up" questions) and c) avoid that you as interviewers speak all at once or "compete" to have a word.
- Keep track of time so you are sure you will get through all topics/questions within the time frame you have agreed upon with the interviewee at the beginning of the interview. Typically, qualitative interviews last 1-1½ hour. But as it can be hard to take part in phone/online interviews, we would recommend aiming for 1 hour only.

Due to the Corona situation the interviews need to be performed either online, e.g. via Skype, or over the phone (slide from online RESPOND meeting):



As the slide shows, there are pros and cons for each alternative (online or phone). It is up to you to decide (though we would recommend online interviews, if possible) – and here, your insights about the interviewees are particularly important for making the decision.

One approach might be to ask the interviewees what they would prefer themselves (e.g. ask when you set up an appointment for the interview). Also, remember that Skype for Business (and probably also "regular" Skype?!) can be used to call phone numbers. This can be useful as it allows you to use the recording features of Skype to tape the interview (instead of using another app for this). At AAU we used this feature with success.

3. Time schedule

Here is a proposal for the time schedule for T6.3 (cf. the discussion at the online partner meeting):

May 2020 Pilot partners prepare interview guides related to relevant use cases (with support from AAU) and set up interview appointments with pilot households.

June 2020 Pilot partners carry out interviews (5-10 per pilot site). *We know that some partners might find this too early, so you might do (some) interviews also in July. But for practical matters, it would be good to have as many interviews in June as possible…*

15th July 2020 Pilot partners report findings from interviews as summaries, which is sent to AAU for analysis and final reporting. AAU will provide instructions/template for these summaries by end of May. *Again, some partners might find it necessary to postpone some of these to later. But no later than 1st of August. The original deadline of D6.3 is July, but if all interview summaries are delayed to 1st of August, we need to postpone the delivery two months (as the AAU-people will be on holiday much of August).*

July 2020 AAU makes the final analysis across pilot sites (on basis of summaries) and prepares the deliverable by 31st of July. *Again, this might be postponed (cf. the previous) – but it would be the ideal to keep the originally planned deadline…*

Please, let us know if you have any comments or suggestions regarding the above time schedule. Also, let us know what you think is the realistic schedule and deadlines in your pilot case.

Henrik & Toke (AAU) / 11.05.2020

ANNEX 2: QUALITY OF HEAT DR ACTIONS

Successful DR actions (green), DR with anomalies (orange) and unsuccessful DR actions (red)

Dwelling No.	Comments	Test week 1 3. February - 9. February	Test week 2 10. February - 16. February (holiday week)	Test week 3 17. February - 23. February	Test week 4 24. February - 1. March	Test week 5 2. March - 8. March	Test week 6 9. March - 15. March	Test week 7 16. March - 22. March	Test week 8 23. March - 29. March	Test week 9 30. March - 5. April	Test week 10 6. April - 12. April
DR action	Thermostat remotely controlled	No DR actions (baseline)		7 am: set-points lowered to 16°C 8 am: set-points back to "preferred set point"		4 am: set-point raised 1°C above "preferred set point" 6 am: set-points lowered to 16°C 9 am: set-points back to "preferred set point"		6 am: set-points lowered to 16°C 9 am: set-points back to "preferred set point"		No DR actions (baseline)	
Aarhus_01				0/5	0/5	2/5	4/5	4/5	5/5		
Aarhus_02	No device found			0/5	0/5	0/5	0/5	0/5	0/5		
Aarhus_03				5/5	5/5	5/5	5/5	4/5	5/5		
Aarhus_04				5/5	4/5	4/5	4/5	3/5	0/5		
Aarhus_05				5/5	3/5	5/5	3/5	4/5	5/5		
Aarhus_06				5/5	5/5	4/5	4/5	0/5	0/5		
Aarhus_08				5/5	4/5	4/5	5/5	0/5	0/5		
Aarhus_09				5/5	5/5	5/5	5/5	5/5	4/5		
Aarhus_11	No quantification			?	?	?	?	?	?		
Aarhus_15	No quantification			Maybe DR action	Maybe DR action	Maybe DR action	Maybe DR action	Maybe DR action	Maybe DR action		
DR Scheme		Nothing	Nothing	1h DR	1h DR	3h DR with preheating	3h DR with preheating	3h DR	3h DR	Nothing	Nothing

ANNEX 3: INTERVIEW GUIDE – INTERVIEW WITH PARTICIPANTS IN THE AARHUS DR HEAT TRIAL

1. Research questions

A. In what ways have the informant (and the others in the household) experienced the experiment of controlling heat in the home? Both in general and specifically in relation to thermal indoor climate (temperature and draft)?
   - Differences in perceptions between household residents?

B. How has the informant experienced participating in the RESPOND experiment?
   - This question has a broader focus and also deals with experience in the installation of equipment, non-working technology, uncertainty about the design of the experiment, etc.

C. What thoughts do the informant have about a future scenario of external control of the heat in the home?
   - What kind of control is acceptable? Which is not?
   - What can motivate the informant to accept external control of the heat? (Economy, environment, doing something for the community ...)

In the following, the above general questions are translated into specific interview questions. In general, a method is followed, where for each topic an overall/open question is first asked, which is followed up by more specific questions.

2. Interview guide

Introduction (5 min.):

- Thank you for your participation in the interview!
- Brief background and purpose: As you know, we have made an experiment where we have controlled the heat in your home. Your experience with this is important to us. We have a number of questions that we would like to ask.
- Present ourselves briefly: THC and HNK. Role distribution ("labor division"): THC asks most questions and HNK complements along the way ("when I forget something" 😉). *Tip: If HNK normally turns off his microphone, THC can see if HNK would like to ask questions when he "opens" his microphone.*
- Recording: We would like to record the interview for documentation and for later analysis. OK with you? Of course, we guarantee confidentiality/anonymity.
- During the interview we will ask for your notes in the "log book". Therefore, you may want to keep the log at hand.
- There are no right or wrong answers. We are interested in your/your family's experiences.
- Duration: Approx. 1 hour.
- Let's get started!

Topic:	**Aim:**	**Questions:**
About the informant and everyday life in recent weeks	- Refresh who the informant is. - Establish understanding of everyday life in the home since the	First a few questions about you, your household and your everyday life since the beginning of February: • Brief - just for our refreshment: Briefly tell who you? • How many have you lived in the apartment since the beginning of February? Who?

5 min.	beginning of February (context)	• What does a typical weekday look like for you and the rest of the family?
		• What has been the pattern of how much you have been home - and when - in recent weeks (since the beginning of February)? Has it been a normal period? Or different than usual?
		  ○ Changes due to the Corona-situation? Or as usual?
		  ○ Overnight guests? When?
		  ○ Have you had periods where you have been away? Vacation?
		  ○ Have you been doing other things at home than you normally would have made?

Experience of the experiment with external control (A)
 	
20-30 min.
	Uncover the informant's and other residents' experience of the thermal indoor climate etc. over the trial period – however, with an initial question about what "heat" generally means to them …	• First, I would like to ask: What will it take for you to feel comfortable indoors in relation to heat and temperature?
		• Do you find sometimes that the temperature/the heat is not right in your dwelling/a room? What do you do then?
		  ○ Do you agree when the temperature/the heat is right in your home?
		• How have you experienced the temperature in your apartment since the beginning of February and up to today?
		  ○ Have you experienced periods/situations where staying in the apartment has not been comfortable? If yes: Describe these.
		  ▪ What? What time of day? Where in the apartment? What did you do then?
		  ▪ Others with the same experience?
		  ▪ How often? One or more times?
		  ▪ What do you think was the reason for the experience?
		• How has it been over the past few days? Since Monday?
		• Have others in the household had experiences of discomfort / lack of heat since the beginning of February?
		  ○ Who? What? When? Where?
		  ○ What did they do?
		  ○ What was the reason?
		• Have there been differences in your experiences of the heat in the apartment? In what ways?
		  ○ Do you have a clue as to what is the cause of the various experiences?
		• In your family, have you talked about your experience of the heat over the last few months?
		  ○ If yes: What have you been talking about?
		  ○ Have you talked more about it than usual? Why?

		• Log book: Have you written anything in the log book? Can you describe what and how much you have written? Is there a typical pattern in things? Can you give a few examples?
		  ○ If there are only a few things, ask the informant to read it one by one.
		• Compared to a normal winter (e.g. last year), do the last few months of experience of the heat in the apartment differ from what you usually experience? If yes:
		  ○ In what ways does it differ?
		  ○ What do you think is the reason for the difference?
		• In addition to what we have already talked about: Are there other things about your experiences of the heat in the last months you want to add?

Experience of participation in the study generally (B)
10 min.
	Uncover other types of experiences and conditions than heat associated with the experiment	• In addition to the heat, have you had other experiences with the experiment and the new thermostats?
		  ○ Positive experiences? Things that are better than before?
		  ○ Negative experiences? Things that bother or "tease" you?
		• What is your overall experience with the new thermostats?
		  ○ Do you experience a difference compared to the old thermostats? What kind of difference?
		• How have you used the new thermostats?
		  ○ Have you changed the setting? How? How often? And in which rooms? Other things?
		• Have you used the new thermostats in a different way than the old ones?
		• How much do you normally adjust on your thermostats?
		  ○ When, where and how? In special situations?
		• Do you feel that you control the heat in your home?
		  ○ Are there situations where it is particularly important to have control?
		• Would you like to keep the new thermostats after the experiment?
		  ○ Why (not)?
		• Have you talked to other participants in the experiment about your experiences? What have you been talking about?
		• What thoughts have you had along the way on how the heat has been controlled in your home?

		• What is your overall experience of being part of this experiment?

Future scenarios for control of heat (C)
 	
10 min.
	The informant's thoughts on future scenarios for control of heat?	*Intro (from the focus group): For various reasons, the district heating suppliers would like to make it possible to time-shift some of the heating in homes. The most important reason for this is that the suppliers in various areas are experiencing a problem with delivering enough heat (e.g. if there has been new-built of homes) – especially in the morning when the heat consumption peaks due to showering etc. This means that the suppliers either have to invest in upgrading the pipes in the ground (which might cost a lot of money and make the heat more expensive for customers) or – alternatively – find ways to time-shift some of the consumption away from the peak hours. One way to do the latter is to install equipment in homes that can control the heating in the morning. Just like we did in your apartment. In this way, the supply companies can switch off the heat briefly for a few hours in the morning. It can save companies money - and thus consumers can save money in the end. In some cases, it can also mean higher efficiency in the system and thus lower energy consumption and CO_2 emissions. Over the past weeks we have variously controlled heat in your apartment …*
		
		• Now that you have participated in the experiment, what do you think about the possibility of letting the district heating company control the heat in your apartment? I.e. switch off the heat for a period in the morning?
		  ○ What problems/difficulties could this cause for you?
		  ○ Are there times when it would be OK for the district heating company to control the heat in the home? And times when it wouldn't be OK?
		  ○ How much can the company regulate the heat?
		
		• What would it take for you to say yes to such a scheme?
		  ○ Motivation: Money (economy)? Environment? Do something good for the community? Other things?
		  ▪ Economy: How much should you save if you were interested in letting the district heating company control the heat? For example, DKK 1,000 per year?
		  ○ Improvement: Improvements in the technique or the way heat is controlled in relation to what you have experienced lately?
		
		• Are there certain rooms where you would not be able to accept a remote control of the heat?
		  ○ Which? And why?

		• Could it be beneficial if there was some extra heating before turning off the heat? Why (not)?
Outro		• Finally, is there anything you would like to add to the things we've talked about? Or something that we haven't asked? *Thanks for the help!*

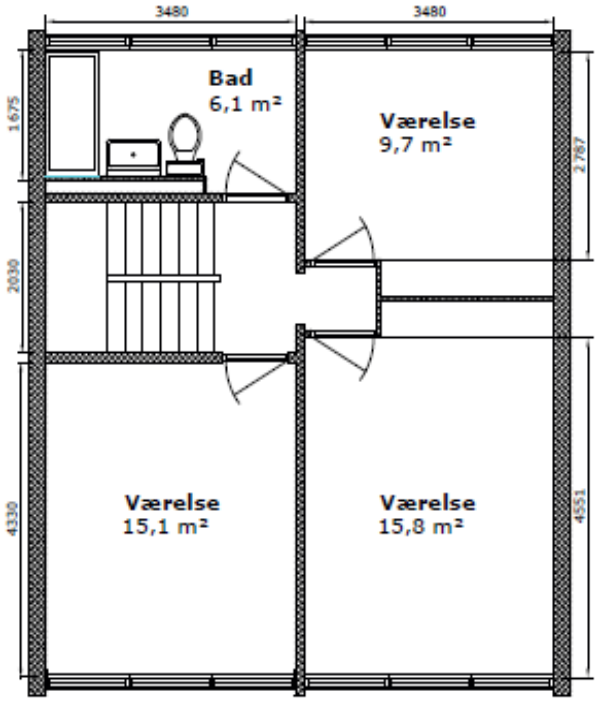
3. Conditions to keep *in mind* during the interview

- The informants' experiences related to the concrete control of the heat (the trial protocol) are likely to get mixed with experiences that are caused by possible technical challenges (e.g. technical errors on thermostats or the repeated need to "restart" thermostats). It is to be expected that the informants themselves have difficulty distinguishing these things from one another. Therefore, in the interview situation, the interviewer must pay particular attention to this complexity and be careful to ask detailed questions about experiences (time, place, situation) so that we can distinguish later in the analysis between their cause.
- Experimental Protocol design (summarized - see also table below):
    - Test week 1-2 (3/2 – 16/2):
      "Reference weeks 1", doing nothing - Baseline 1.
    - Test week 3-4 (17/2 – 1/3):
      7 am: temperature set-points lowered to 16°C (unless already below 16°C, then do nothing)
      8 am: temperature set-points back to "preferred set point"
    - Test week 5-6 (2/3 – 15/3):
      4 am: temperature set-point raised 1°C above "preferred set point"
      6 am: temperature set-points lowered to 16°C (unless already below 16°C, then do nothing)
      9 am: temperature set-points back to "preferred set point"
    - Test week 7-8 (16/3 – 29/3):
      6 am: temperature set-points lowered to 16°C (unless already below 16°C, then do nothing)
      9 am: temperature set-points back to "preferred set point"
    - Test week 9-10 (30/3 – 12/4):
      "Reference weeks 2", doing nothing - Baseline 2
    - *Only external control on weekdays - not during weekends.*
- The log book contains information about date, name and experience/comments.
- The apartments have three floors – see floor plan at the end of the document:
    - Basement: Basement room
    - Ground floor: Living room, Kitchen, hallway and small toilet
    - 1st floor: 3 bedrooms and bathroom. ***Bathroom exempt from external control!***

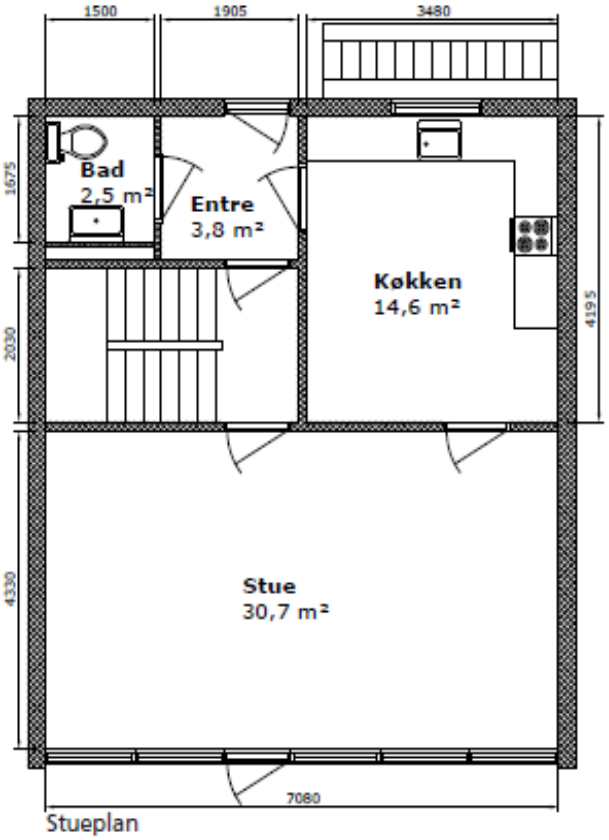
The experimental protocol:

	Doing nothing	**Switched off for one hour**	**Switched off for three hours**
Doing nothing	Test week 1-2 Week 9-10	-	-
With preheating +1°C for 2 hours	-	-	Test week 5-6
Without preheating	-	Test week 3-4	Test week 7-8

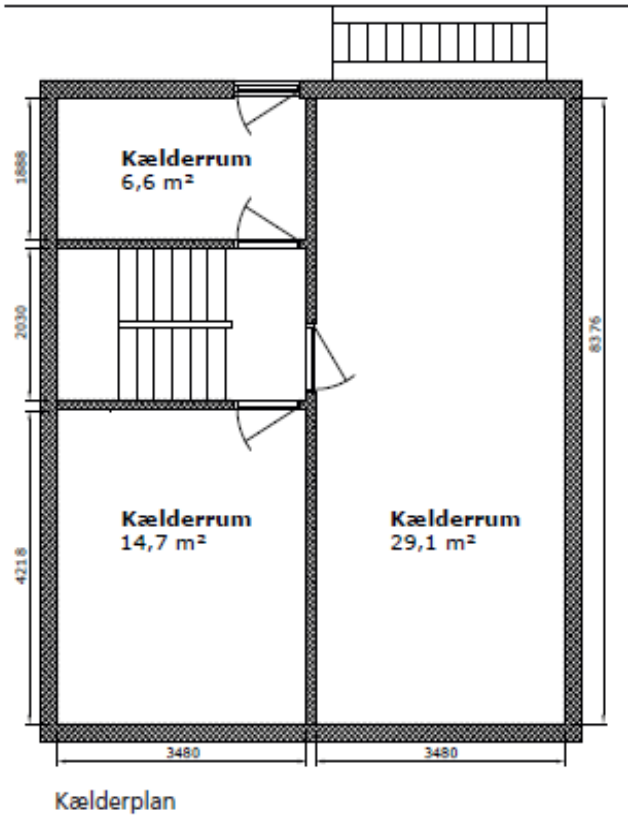
Floor map:



1. sal



Stueplan



Kælderplan

ANNEX 4: INTERVIEW GUIDE – INTERVIEW WITH PARTICIPANTS IN THE AARHUS TRIAL WITH APP AND ELECTRICITY DR

1. Research questions

D. How do the participants use the RESPOND app?
   a. The usage practice (how) and the participants' interpretations of their own practice (why)?
   b. Problems and challenges?
   c. Things they are happy for/appreciate about the app?

E. Ideas of improvements?
   a. Something they are missing (features or options)?
   b. Something they think could have been made in a smarter way?

F. Interest of (willingness to) moving electricity consumption according to the local solar power production?
   a. Specific (personal) experiences with moving consumption related to the use of the app?
   b. What might in general motivate the participants to move consumption to optimize consumption of local power production?

In the following, the above research questions are "translated" into specific interview questions. Typically, each of the overall themes (A, B & C) is opened with an overall/open question, which is then followed up by more specific questions.

2. Interview guide

Introduction (5 min.):

- Thanks for participating!
- Tell briefly about background and aim of interview
- Recording: We would like to record the interview for documenting and later analysis. The recording will not be shared with others – and we guarantee your anonymity. Can you allow this?
- No "right or wrong" answers. We are interested in learning about your experiences.
- Duration: About 1 hour
- Let's get started!

Topic:	**Aim:**	**Questions:**
About the informant and the everyday life within recent weeks (the time of the trial) 5 min.	- Who the informant is? - Establish an understanding of the everyday life in the dwelling (provides context for understanding experiences with pilot trials)	To begin with, I have a few questions about you, your household and your everyday life: • Please explain who you are? • How many people are living in your apartment? Who are they? • How does a typical every day look like for you and your family? Who does what and when? ○ At which hours of the day are people staying at home in the apartment?

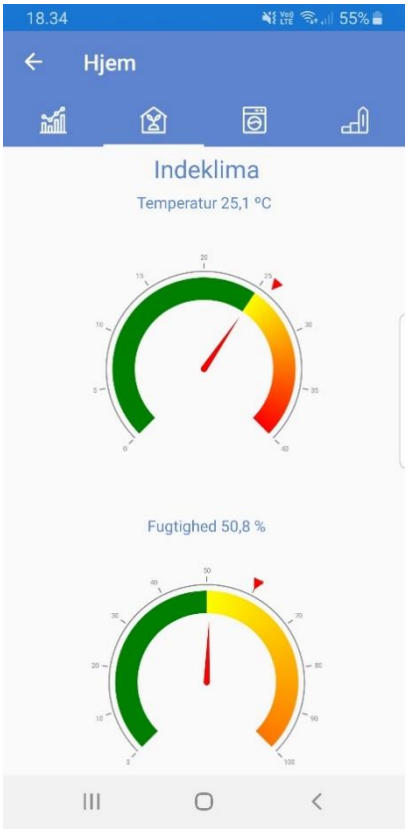
		• How do weekends differ from weekdays regarding the daily routines and rhythm? How much are you at home during the weekend?
		
		• How much have you been at home – and when – since the middle of May [= the time when the mobile app trial began with notifications to households]? Has it been a ”regular” period? Or different from what is normal?
		  ○ Changes due to Corona?
		  ○ Have you been away for longer periods?

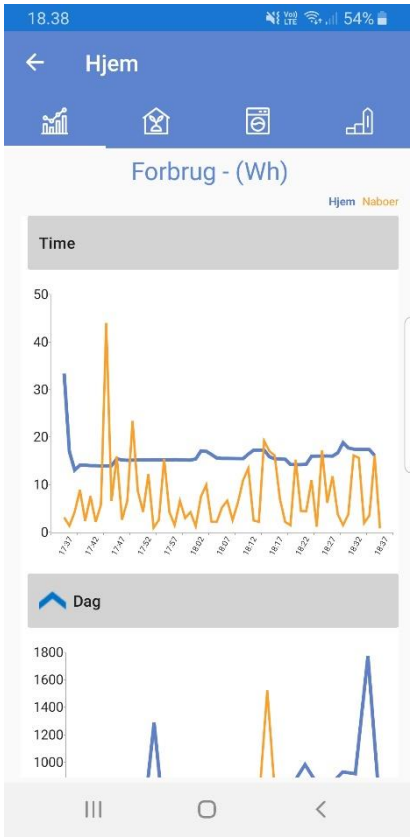
Experiences with the RESPOND app (A)
 	
20-30 min.
	To uncover the interviewee's and other family members' use of the app and their thoughts about this.	• Have you or other members of the family used the RESPOND app? (If the answer is “no”, see later questions in red)
		
		• What did you use it for (to) the last time you used the app? How did you use it? Please describe the situation and how you used the app in detail.
		  ○ What was the occassion?
		  ○ Who did what? And when? And in connection with what?
		• Other examples of the use of the app?
		  ○ Please provide some concrete examples of usage?
		  ○ In what situations do you typically use the app? And for what purposes?
		• Who uses the app (most)? And why?
		• How often do you use the app? Has this changed over time?
		
		• What do you like about the app? Things that work well and are a good help?
		• What do you think works less well or bad?
		• Are there functions or features that you would imagine that you would like to continue to use also after the end of the RESPOND trial (if it were possible)?
		The following questions focus on specific (selected) sections (features) of the mobile app – the questions are asked if these specific sections <u>have not</u> been covered by the above questions:
		
		• Have you been looking at the pages about **the indoor climate, temperature and humidity**?
		  ○ If yes: Ask about what the interviewee has used this to and how s/he has experienced this section?
		• To families who also took part in the Aarhus heat DR trial: Have you been looking at the pages about the **thermostats and the control of these**?
		  ○ If yes: Ask about what the interviewee has used this to and how s/he has experienced this section?
		• Have you been looking at the pages about **your own energy consumption and compared to neighbours**?

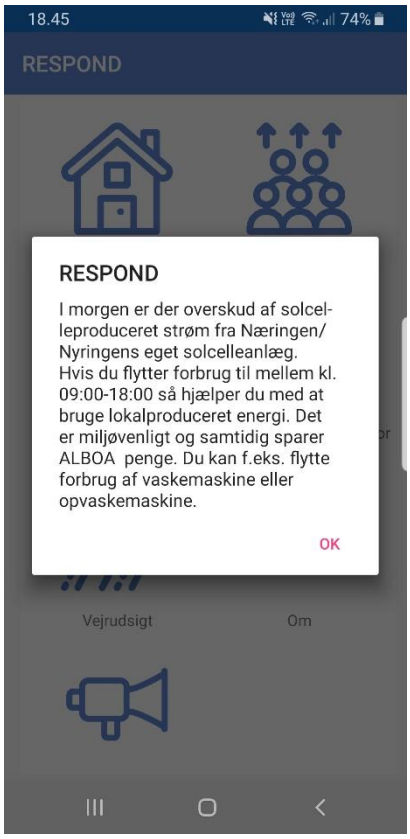
		○ If yes: Ask about what the interviewee has used this to and how s/he has experienced this section? • Do you recall having received **messages (notifications)** from the app? ○ If yes: Ask about what the interviewee has used this to and how s/he has experienced this section? • **Something else** you have been using or looked at in the app (in addition to what we have talked about so far)? • In case neither the interviewee or any other member of the family use the app, ask instead: What's the reason why you or other members of your family have not used the app? ○ Have you ever opened the app? ▪ What did you do? Please describe? ▪ What did you think about the app? ▪ Why haven't you used the app since then? ○ Have you – or other members of the family – had downloaded the app and installed it on your phone? ▪ Why (not)? Did you experience any problems? Why haven't you used the app since then?
Suggestions for improvement (B) 10 min.	Get the interviewee's own ideas on what could be improved if they would find it appealing to use the app	• Are there things you think could have been made in a "smarter" or better way to improve the app? What? ○ Features (functionalities) you are missing? E.g. some type of information? ○ In case of the above: What would you use this type of information or features for? On which occasions?
Moving consumption and the interest in doing this (C) 15 min.	To provide knowledge about the interviewee's experiences with time-shifting consumption (DR) – and to get insights into what could make the interviewee more inclined (motivated) to time-shift consumption	• During the trial with the app, have you – or any members of your family – moved your electricity consumption in time in relation to the power that the PV of the housing association is producing? If so: ○ Please describe in detail what happened last time you (or another member of your family) time-shifted your consumption? ▪ When (date and time of the day)? ▪ What did you move more specifically (e.g. laundering or dishwashing)? How did you do this in practice? (e.g. by using timers on the dishwasher etc.) ▪ Who was aware of the need to move consumption? ▪ What made you aware of moving the consumption? ▪ Who took part in moving the consumption ("who did it")? ▪ Was it something you planned together / talked with each other about?

		○ Other examples of moving consumption? Other situations? ○ How often do you move your consumption? E.g. weekly, daily? Always when notifications? Or? • What has been your experiences with moving consumption? ○ Something that has been difficult or inconvenient? ○ Something that didn't went as planned? ○ Something that was easy/convenient? • What are the reasons why you move consumption? ○ Saving money, to use "own" energy, do good for the environment, do good for the local community, or? • Is it something that you consider continuing to do (even after the end of the RESPOND trial)? Why (not)? • Have you been moving consumption in relation to the local PV power production also before the RESPOND trial? How and why? • If the interviewee (or family) do not time-shift consumption: Have you – or other members of the family – been considering moving consumption in time? If so: Why didn't you do it eventually? ○ What type of measures could make you consider moving your own consumption in time (if any)? • More generally, what do you think about moving consumption in order to optimize the consumption of the locally produced PV power? Is it something that makes sense to you? Why (not)? ○ Does it make a difference that it is the PV power owned by the housing association (compared to owned by yourselves or others)?
Outro		• Finishing the interview: Is there anything you would like to add to what we have already been talking about? Or something I haven't asked about in relation to the app or your local power production? *Thanks for your help!*

3. Selected sections of the mobile app (asked about in part A of interview)







ANNEX 5: INTERVIEW GUIDE – INTERVIEW WITH PARTICIPANTS IN MADRID PILOT ABOUT ELECTRICITY DR EXPERIENCE FROM 27/04 -10/05

1. RESEARCH QUESTIONS

A. How has the informant (and the others in the household) experienced participating in the experiment of **changes in the energy prices** in the home and the preferred **communication channels** for the RESPOND trial notifications?
   - This question deals with experience of the households about experiment with "happy hours": problems to move consumption, what was difficult for them? If they have been able to move consumption, etc.
   - Differences in perceptions between household residents?
   - This question deals with preferences about notifications through RESPOND APP, SMS, etc. Which are the preferred channels of communication and why?

2. INTERVIEW GUIDE

Topic:	**Aim:**	**Questions:**
About the informant and the everyday life within recent weeks (the time of the trial)	- Who the informant is? - Establish an understanding of the everyday life in the dwelling (provides context for understanding experiences with pilot trials)	To begin with, I have a few questions about you, your household, and your everyday life: • Please explain who you are? • How many people are living in your apartment? Who are they? • How does a typical every day look like for you and your family? Who does what and when? • Other aspects that freely came up during the conversation
Experiences with **changes in the prices ("happy hours")** and **communication channels** (A)	To uncover the interviewee's and other family members' experience about having free hours of energy and their thoughts about this, also the preferred communication channels for the notifications	1. Are you aware that you have 2 hours of free energy per day? Do you know which are the free hours? (YES/NO) 2. Have you received a notification informing about the "happy hours" through the RESPOND APP and through a SMS? (YES/NO) (if answers no/no in the first two questions, he/she didn't know that he/she had free hours, go to the last question (3b.) 3. Which channel do you prefer or is more useful APP/SMS? 4. Are all the inhabitants of the dwellings aware, are you motivated to move consumption to those "happy hours"? 5. Did you try to move consumption to the following hours of the day, 15:00 a 16:00 y de 22:00 a 23:00?

		6. Have you succeeded, are you taking advantage of the “happy hours”? Why? Which problems do you find and how cold we help you to achieve it? 7. Do you know why we have chosen those slots of the day and how does a change influence electricity consumption habits? 8. Would you agree to try for two weeks that as a reminder we send you a notification through the APP just when a “happy hour” is going to start? If “NO” to the first question: 3b) Which channel of communication could we use to send you the notifications?
Outro		• Finishing the interview: Is there anything you would like to add to what we have already been talking about? Thanks for your help!

ANNEX 6: INTERVIEW GUIDE - INTERVIEW WITH PARTICIPANTS IN MADRID PILOT ABOUT RESPOND APP AND ELECTRICITY DR EXPERIENCE FROM 01/06/2020

1. RESEARCH QUESTIONS

A. How was the informant (and the others in the household) **APP experience**?
   - This question deals with familiarity/usage of RESPOND app, preferred communication channels, improvements.

B. How has the informant (and the others in the household) experienced participating in the experiment of **changes in the energy prices** in the homes after their first feedback from the first interviews were implemented, **future scenario** with **automated DR actions, air conditioner patrons** and the preferred **communication channels** for the RESPOND trial notifications?
   - This question deals with experience of the households about experiment with "happy hours": succeeds and problems to move consumption, what was difficult for them? If they have been able to move consumption, etc.
   - Differences in perceptions between household residents?
   - Future scenario with automated control actions.
   - Air conditioner patrons.

2. INTERVIEW GUIDE

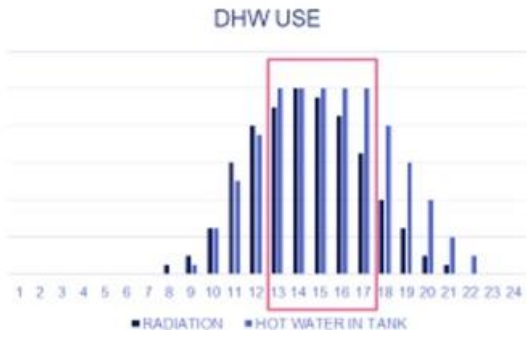
Topic:	**Aim:**	**Questions:**
RESPOND APP experience (A)	To uncover the interviewee's and other family members' experience with RESPOND APP	1. Have you downloaded/updated the app? Do you use the app? Which functionalities of the app do you find useful and you use? Why not (if he/she doesn't use it)? Which communication channel do you prefer? Any improvement that would be useful for your everyday life?
Experiences with **changes in the prices ("happy hours")** in the homes after their first feedback	To uncover the interviewee's and other family members' experience about having free hours of energy and their thoughts about moving consumption,	1. Are you aware that you have 4 hours of free energy per day? Do you know which are the free hours? (yes/no) (if answers no/no, so in the first question, he/she didn't know that he/she had free hours, go to the last question 3a.) 2.Did you try to move consumption to the following hours of the day, 15:00 a 17:00 y de 22:00 a 24:00? In which situations?

from the first interviews were implemented, and **future scenario** with **automated control actions, air conditioner patrons** and preferred **communication channels** (B)	automated control actions	What type of consumption did you moved? What was easy/difficult about doing it? 3. Did the change in the happy hours (from 2 to 4 hours per day) help you to move consumption to those free slots? Have you succeeded, are you taking advantage of the "happy hours"? Are the current happy hours enough to run appliances during the time with energy at 0€ price? If not, why? Which problems do you find and how could we help you to achieve it? 4.Would you allow automated control actions with devices that can be switch on-off? Reasons and motivations why? Examples: to lower the temperature of air conditioner or do not let the washing machine or dishwasher turn on at peak times. 5.Are all the inhabitants of the dwellings aware are motivated to move consumption to those "happy hours"? 6.We will send notifications 15 min before the happy hours start. Do you think is a good measure. 7.Regarding the air conditioner: -Cooling schedules: When and at which temperature? If "NO" to the first question: 3a. If household doesn't know happy hours) Which channel of communication could we use to send you the notifications?
Outro		• Finishing the interview: Is there anything you would like to add to what we have already been talking about? Thanks for your help!

ANNEX 7: INTERVIEW GUIDE: INTERVIEW WITH PARTICIPANTS IN MADRID PILOT ABOUT DHW - SOLAR THERMAL SYSTEM (UC8)

1. INTERVIEW GUIDE

1. DID YOU NOTICE ANY REDUCTION IN THE GAS BILL, THANKS TO THE INSTALLATION OF SOLAR THERMAL PANELS?
2. HOW WOULD YOU REACT IF YOU RECEIVED ANY NOTIFICATION (APP, SMS, CALL) REGARDING DHW? (MESSAGE EXAMPLE: "WE RECCOMMEND YOU TO USE THE DHW FROM 12:00 UNTIL 18:00 TO TAKE ADVANTAGE OF THE SOLAR THERMAL GENERATION.")
3. WOULD YOU BE, OR HAVE YOU BEEN WILLING TO ADAPT YOUR DHW CONSUMPTION TO THE SUNNIEST HOURS IN THE DAY, IN ORDER TO OPTIMIZE THE USE OF SOLAR THERMAL GENERATION?



4. DID YOU NOTICE ANY DIFFERENCE DURING THE SUMMER SEASON? (EXAMPLES: IN SUMMER THAT SOLAR THERMAL PRODUCES MORE THAN IN WINTER, DID YOU NOTICE ANY REDUCTION IN THE GAS BILL OR DID YOU NOTICE THAT THE DHW TEMPERATURE WAS DIFFERENT IN SUMMER?)
5. WOULD YOU BE WILLING TO MAINTAIN THE INSTALLATION OF SOLAR THERMAL PANELS EVEN IF THE BILL REDUCTION WERE VERY LOW, IN ORDER TO CONTRIBUTE TO IMPROVE ENVIRONMENTAL CONDITIONS?
6. WOULD YOU INVEST IN THE INSTALLATION OF SOLAR THERMAL PANELS?

ANNEX 8: INTERVIEW GUIDE – INTERVIEW WITH PARTICIPANTS IN ARAN ISLANDS PILOT (UC1, UC2 AND UC4)

The interviews in Aran Islands will occur with the house participants of the RESPOND project. The interviews should have the following characteristics:

1. The interviews will be held on Skype or another platform (preferably using video call) chosen by the participant. The participant will be asked about the possibility to recording the interview. If they agree, the interview will be recorded.

2. The interviews should take at least 30 minutes and be no longer than 1:30. In the beginning the participant should be informed that the interview should take approximately 1 hour.

3. The interviews should take place preferentially between 20 and 24 of July If the House didn't have demand response events happening during this period, the interview should be postponed (but occurring no longer than end of July).

Research questions

The objective of the interviews will be to analyse the behaviour of the costumers during the demand response events and their interaction with the RESPOND project. There will be general questions that will be applied for all the houses and specific questions based in the Use Cases that the Houses are participating.

A. How do the participants interact with the RESPOND app?

a. The usage practice (how) and the participants' interpretations of their own practice (why)?

b. Problems and challenges?

c. Things they are happy for/appreciate about the app?

B. Ideas of improvements?

a. Something missing (features or options)?

b. Something that could have been made in a smarter way.

C. Interest in moving/reducing the consumption

a. The costumer changed the behaviour after having access to the data provided by the app?

b. There is interest in changing electricity consumption?

c. Specific (personal) experiences with moving consumption

Interview Guide

1) Introduction (5 min.):

- Thanks for participating in the project

- Recording: We would like to record the interview for documenting and later analysis. The recording will not be shared with others – and we guarantee your anonymity. Can you allow this?
- Timing: This should take about 1h
- There are no right or wrong answers. We are interested in learning about your experiences.

2) About the informant and the everyday life within the time of the events (5 min.):

- Who the informant is?
- Establish an understanding of the everyday life in the dwelling (provides context for understanding experiences with pilot trials)

Questions:

To begin with, I have a few questions about you, your household and your everyday life:

- Please explain who you are?
- How many people are living in your apartment? Who are they?

How does a typical every day look like for you and your family? Who does what and when?

- At which hours of the day are people staying at home?
- How do weekends differ from weekdays regarding the daily routines and rhythm? How much are you at home during the weekend?
- How much have you been at home – and when – since June? [= the time when the mobile app trial began with notifications to households]? Has it been a regular period? Or different from what is normal?
- Changes due to Corona?
- Have you been away for longer periods?

3) How do the participants interact with the RESPOND app? (20-30 min.):

- To uncover the interviewee's and other family members' use of the app and their thoughts about this.

Questions:

Have you or other members of the family used the RESPOND app? (If the answer is "no", see later questions in red)

What did you use it for (to) the last time you used the app? How did you use it? Please describe the situation and how you used the app in detail.

- What was the occasion?
- Who did what? And when? And in connection with what?

Other examples of the use of the app?

- Please provide some concrete examples of usage.
  - In what situations do you typically use the app? And for what purposes?
  - Who uses the app (most)? And why?
  - How often do you use the app? Has this changed over time?
  - What do you like about the app? Things that work well and are a good help?
  - What do you think works less well or bad?

Are there functions or features that you would imagine that you would like to continue to use also after the end of the RESPOND trial (if it were possible)?

The following questions focus on specific (selected) sections (features) of the mobile app – the questions are asked if these specific sections have not been covered by the above questions:

Have you been looking at the pages about the indoor climate, temperature and humidity?

- If yes: Ask about what the interviewee has used this to and how s/he has experienced this section?

Have you been looking at the pages about your own energy consumption and compared to neighbors?

- If yes: Ask about what the interviewee has used this to and how s/he has experienced this section?

Do you recall having received messages (notifications) from the app?

- If yes: Ask about what the interviewee has used this to and how s/he has experienced this section?

Something else you have been using or looked at in the app (in addition to what we have talked about so far)?

In case neither the interviewee nor any other member of the family uses the app, ask instead:

- What's the reason why you or other members of your family have not used the app?

Have you ever opened the app?

- What did you do? Please describe?
- What did you think about the app?
- Why haven't you used the app since then?

Have you – or other members of the family – had downloaded the app and installed it on your phone?

- Why (not)? Did you experience any problems? Why haven't you used the app since then?

4) Ideas of improvements? (10 min.):

Get the interviewee's own ideas on what could be improved if they would find it appealing to use the app.

Questions:

Are there things you think could have been made in a "smarter" or better way to improve the app? What?

- Features (functionalities) you are missing? E.g. some type of information?
- In case of the above: What would you use this type of information or features for? On which occasions?

5) Interest in moving/reducing the consumption (15 min.):

To provide knowledge about the interviewee's experiences with the DR events – and to get insights into what could make the interviewee more inclined (motivated) to do the actions.

Questions:

During the trial with the app, have you – or any members of your family – moved your electricity consumption in time? (If the answer is "no", see later questions in red)

- Please describe in detail what happened last time you (or another member of your family) time-shifted your consumption?
    - When (date and time of the day)?
    - What did you move more specifically (e.g. laundering or dishwashing)? How did you do this in practice? (e.g. by using timers on the dishwasher etc.)
    - Who was aware of the need to move consumption?
    - What made you aware of moving the consumption?
    - Who took part in moving the consumption ("who did it")?
    - Was it something you planned together / talked with each other about?
    - Other examples of moving consumption? Other situations?
    - How often do you move your consumption? E.g. weekly, daily? Always when notifications? Or?
- What has been your experiences with moving consumption?
    - Something that has been difficult or inconvenient?
    - Something that didn't went as planned.
    - Something that was easy/convenient?
- What are the reasons why you move consumption?

  - Saving money, to use “own” energy, do good for the environment, do good for the local community, due to grid difficulties in the island, or?
  - Is it something that you consider continuing to do (even after the end of the RESPOND trial)? Why (not)?

- Have you been moving consumption in relation to the local PV power production (if applicable) also before the RESPOND trial? How and why?

If the interviewee (or family) do not time-shift consumption:

Have you – or other members of the family – been considering moving consumption in time? If so:

- Why didn’t you do it eventually?
- What type of measures could make you consider moving your own consumption in time (if any)?

More generally, what do you think about moving consumption in order to optimize the consumption of the locally produced PV power? Is it something that makes sense to you? Why (not)?

6) Others (5 min.):

Finishing the interview: Is there anything you would like to add to what we have already been talking about? Or something I haven’t asked about in relation to the app or your local power production?

Thanks for your help!

ANNEX 9 ORIGINAL DANISH SURVEY QUESTIONNAIRE

On the following pages, the original Danish questionnaire is shown. The tenants filled in the questionnaire in the web-based system SurveyXact. An English translation of the questionnaire is shown in Annex 10.

Dear participant in the RESPOND project,

Tak fordi at du vil hjælpe os ved at besvare dette spørgeskema om **dine oplevelser i relation til temperaturforholdene i din bolig siden i mandags i denne uge**. Du kan svare til og med fredag i denne uge.

Du skal trykke på "Næste" nederst på siden for at komme videre til spørgsmålene, og du kan til enhver tid komme tilbage til et allerede besvaret spørgsmål ved at trykke på "Forrige".

Du kan når som helst lukke spørgeskemaet og vende tilbage til din besvarelse på et senere tidspunkt, da svarene gemmes automatisk.

Spørgeskemaet er først **færdigudfyldt, når du har trykket på "Afslut" efter det sidste spørgsmål.**

Eventuelle spørgsmål kan rettes til undertegnede.

Med venlig hilsen

Henrik

Henrik N. Knudsen, Seniorforsker, PhD

Institut for Byggeri, By og Miljø (BUILD)

Aalborg Universitet

MB: 2662 2128

hnk@sbi.aau.dk

Siden i mandags i denne uge...

På hvilke tidspunkter har du været i din bolig?

(Sæt kryds ved de tidsintervaller, hvor du har været i boligen siden i mandags)

	Morgen, kl. 6-10	Middag/eftermiddag, kl. 10-16	Aften, kl. 16-22	Nat, kl. 22-6	Jeg har ikke været i min bolig denne dag	Jeg svarer på spørgeskemaet inden denne dag
Mandag	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑	(3) ❑
Tirsdag	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑	(3) ❑
Onsdag	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑	(3) ❑
Torsdag	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑	(3) ❑
Fredag	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑	(3) ❑

Uddyb eventuelt dit svar:

_____

Siden i mandags i denne uge...

Har du oplevet problemer med for lav temperatur?

(1) ❑ Ja

(2) ❑ Nej

Siden i mandags i denne uge...

På hvilke dage har du oplevet problemer med for lav temperatur?

(1) ❑ Mandag

(2) ❑ Tirsdag

(3) ❑ Onsdag

(4) ❑ Torsdag

(5) ❑ Fredag

Hvornår på dagen har du oplevet problemer med for lav temperatur?

(1) ❑ Morgen, kl. 6-10

(2) ❑ Middag/eftermiddag, kl. 10-16

(3) ❑ Aften, kl. 16-22

(4) ❑ Nat, kl. 22-6

I hvilke rum har du oplevet problemer med for lav temperatur?

(1) ❑ Soveværelse (dit)

(2) ❑ Stuen

(3) ❑ Badeværelse på 1. sal

(4) ❑ Køkken

(6) ❑ Kælder

(5) ❑ Andre rum, hvilke? _____

Uddyb gerne dine svar angående oplevede problemer med for lav temperatur:

_____

_____

Siden i mandags i denne uge...

Har du oplevet problemer med for <u>høj</u> temperatur?

(1) ❑ Ja

(2) ❑ Nej

Siden i mandags i denne uge...

På hvilke dage har du oplevet problemer med for høj temperatur?

(1) ❑ Mandag

(2) ❑ Tirsdag

(3) ❑ Onsdag

(4) ❑ Torsdag

(5) ❑ Fredag

Hvornår på dagen har du oplevet problemer med for høj temperatur?

(1) ❑ Morgen, kl. 6-10

(2) ❑ Middag/eftermiddag, kl. 10-16

(3) ❑ Aften, kl. 16-22

(4) ❑ Nat, kl. 22-6

I hvilke rum har du oplevet problemer med for høj temperatur?

(1) ❑ Soveværelse (dit)

(2) ❑ Stuen

(3) ❑ Badeværelse på 1. sal

(4) ❑ Køkken

(6) ❑ Kælder

(5) ❑ Andre rum, hvilke? _____

Uddyb gerne dine svar angående oplevede problemer med for høj temperatur:

_____

_____

Siden i mandags i denne uge...

Har du oplevet problemer med træk (generende luftbevægelse)?

(1) ❑ Ja

(2) ❑ Nej

Siden i mandags i denne uge...

På hvilke dage har du oplevet problemer med træk?

(1) ❑ Mandag

(2) ❑ Tirsdag

(3) ❑ Onsdag

(4) ❑ Torsdag

(5) ❑ Fredag

Hvornår på dagen har du oplevet problemer med træk?

(1) ❑ Morgen, kl. 6-10

(2) ❑ Middag/eftermiddag, kl. 10-16

(3) ❑ Aften, kl. 16-22

(4) ❑ Nat, kl. 22-6

I hvilke rum har du oplevet problemer med træk?

(1) ❑ Soveværelse (dit)

(2) ❑ Stuen

(3) ❑ Badeværelse på 1. sal

(4) ❑ Køkken

(6) ❑ Kælder

(5) ❑ Andre rum, hvilke? _____

Uddyb gerne dine svar angående oplevede problemer med træk:

_____

_____

Siden i mandags i denne uge...

Har du oplevet problemer med de nye termostater?

(1) ❑ Ja

(2) ❑ Nej

Siden i mandags i denne uge...

Hvilke problemer har du oplevet med termostaterne?

Beskriv problemerne (bl.a. hvornår og i hvilke rum de optrådte):

_____

_____

Siden i mandags i denne uge...

Har du oplevet problemer med radiatorerne?

(1) ❑ Ja

(2) ❑ Nej

Siden i mandags i denne uge...

Hvilke problemer har du oplevet med radiatorerne?

Beskriv problemerne (bl.a. hvornår og i hvilke rum de optrådte):

_____

_____

Siden i mandags i denne uge...

Har du oplevet andre problemer med temperaturforholdene i din bolig?

Beskriv problemerne (bl.a. hvornår og i hvilke rum de optrådte):

_____

_____

Hvor tilfreds er du samlet set med temperaturforholdene i din bolig?

Meget utilfreds	Utilfreds	Tilfreds	Meget tilfreds
(1) ❑	(2) ❑	(3) ❑	(4) ❑

FØR du fik de nye termostater

Før du fik de nye termostater - Hvor tilfreds var du samlet set med temperaturforholdene i din bolig?

	Meget utilfreds	Utilfreds	Tilfreds	Meget tilfreds	Har ikke boet i min bolig på denne årstid
Om EFTERÅRET	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Om VINTEREN	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Om FORÅRET	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Om SOMMEREN	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

Uddyb gerne dit svar:

_____

_____

Er der andet, positivt eller negativt, som du ønsker at fremhæve eller blot gerne vil nævne, kan du skrive det her:

_____

_____

Lidt om dig og din familie

Hvilken aldersgruppe tilhører du?

Under 18 år	18 - 29 år	30 - 49 år	50 - 70 år	Over 70 år	Ønsker ikke at svare
(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Hvor mange voksne bor der i din bolig?

___

Hvor mange børn bor der i din bolig?

___

Hvor lang tid har du boet i din bolig?

(1) ❑ Under 1 år

(3) ❑ 1 år eller længere

Mange tak fordi du tog dig tid til at besvare spørgeskemaet.

Du afslutter din besvarelse ved at trykke på "Afslut".

ANNEX 10 ENGLISH TRANSLATION OF SURVEY QUESTIONNAIRE

On the following pages, the original Danish questionnaire is translated into English. The original Danish questionnaire is shown in Annex 9.

Dear participant in the RESPOND project,

Thank you for helping us by answering this questionnaire about **your experiences in relation to the temperature conditions in your home since Monday this week**. You can answer through Friday this week.

You must press "Next" at the bottom of the page to proceed to the questions, and you can return to an already answered question at any time by pressing "Previous".

You can close the questionnaire at any time and return to your answers later, as the answers are saved automatically.

The questionnaire is only **completed when you have pressed "Finish" after the last question.**

Any questions can be directed to the undersigned.

Sincerely,

Henrik

Henrik N. Knudsen, Senior Researcher, PhD

Department of the Built Environment (BUILD)

Aalborg University

MB: 2662 2128

hnk@sbi.aau.dk

Since Monday this week ...

At what times have you been in your home?

(Tick the time intervals where you have been in the home since Monday)

	Morning 6 am -10 am	Noon/afternoon 10 am – 4 pm	Evening 4 am – 10 pm	Night 10 pm – 6 am	I have not been in my residence that day	I answer the questionnaire before this day
Monday	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑	(3) ❑
Tuesday	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑	(3) ❑
Wednesday	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑	(3) ❑
Thursday	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑	(3) ❑
Friday	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑	(3) ❑

Optionally, elaborate on your answer:

_____

Since Monday this week ...

Have you experienced problems with too low temperature?

(1) ❑ Yes

(2) ❑ No.

Since Monday this week ...

On which days have you experienced problems with too low temperature?

(1) ❑ Monday

(2) ❑ Tuesday

(3) ❑ Wednesday

(4) ❑ Thursday

(5) ❑ Friday

What time of the day did you experience problems with too low temperature?

(1) ❑ Morning, 6 am - 10 am

(2) ❑ Noon/afternoon, 10 am - 4 pm

(3) ❑ Evening, 4 pm - 10 pm

(4) ❑ Night, 10 pm - 6 am

In which rooms have you experienced problems with too low temperature?

(1) ❑ Bedroom (yours)

(2) ❑ Living room

(3) ❑ Bathroom on first floor

(4) ❑ Kitchen

(6) ❑ Basement

(5) ❑ Other rooms, which ones? _____

Optionally, please elaborate on your answers regarding experienced problems with too low temperature:

_____

_____

Since Monday this week ...

Have you experienced problems with too high temperature?

(1) ❑ Yes

(2) ❑ No.

On which days have you experienced problems with too high temperature?

(1) ❑ Monday

(2) ❑ Tuesday

(3) ❑ Wednesday

(4) ❑ Thursday

(5) ❑ Friday

What time of the day did you experience problems with too high temperature?

(1) ❑ Morning, 6 am - 10 am

(2) ❑ Noon/afternoon, 10 am - 4 pm

(3) ❑ Evening, 4 pm - 10 pm

(4) ❑ Night, 10 pm - 6 am

In which rooms have you experienced problems with too high temperature?

(1) ❑ Bedroom (yours)

(2) ❑ Living room

(3) ❑ Bathroom on the first floor

(4) ❑ Kitchen

(6) ❑ Basement

(5) ❑ Other rooms, which ones? _____

Optionally, please elaborate on your answers regarding experienced problems with too high temperature: _____

Since Monday this week ...

Have you experienced problems with draught (annoying air movement)?

(1) ❑ Yes

(2) ❑ No.

On which days have you experienced problems with draught (annoying air movement)?

(1) ❑ Monday

(2) ❑ Tuesday

(3) ❑ Wednesday

(4) ❑ Thursday

(5) ❑ Friday

What time of the day did you experience problems with draught?

(1) ❑ Morning, 6 am - 10 am

(2) ❑ Noon/afternoon, 10 am - 4 pm

(3) ❑ Evening, 4 pm - 10 pm

(4) ❑ Night, 10 pm - 6 am

In which rooms have you experienced problems with draught?

(1) ❑ Bedroom (yours)

(2) ❑ Living room

(3) ❑ Bathroom on the first floor

(4) ❑ Kitchen

(6) ❑ Basement

(5) ❑ Other rooms, which ones? _____

Optionally, please elaborate on your answers regarding experienced problems with draught:

_____

____

Since Monday this week ...

Have you experienced problems with the new thermostats?

(1) ❑ Yes

(2) ❑ No.

What problems have you experienced with the thermostats?

Describe the problems (including when and in which rooms they appeared):

_____

_____

Since Monday this week ...

Have you experienced problems with the radiators?

(1) ❑ Yes

(2) ❑ No.

What problems have you experienced with the radiators?

Describe the problems (including when and in which rooms they appeared):

_____

_____

Since Monday this week ...

Have you experienced other problems with the temperature conditions in your home?

Describe the problems (including when and in which rooms they appeared):

_____

_____

How satisfied are you overall with the temperature conditions in your home?

Very dissatisfied	Dissatisfied	Satisfied	Very satisfied
(1) ❑	(2) ❑	(3) ❑	(4) ❑

BEFORE you got the new thermostats

Before you got the new thermostats - How satisfied were you overall with the temperature conditions in your home?

	Very dissatisfied	Dissatisfied	Satisfied	Very satisfied	Have not lived in my home at this time of year
In the FALL	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
In the WINTER	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
In the SPRING	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
In the SUMMER	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

Optionally, please elaborate on your answer:

_____

_____

If there is anything else, positive or negative, that you want to highlight or just want to mention, you can write it here:

_____

_____

Some information about you and your family

What age group do you belong to?

Under 18 years	18 - 29 years	30 - 49 years	50 - 70 years	Over 70 years	Prefer not to answer
(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

How many adults live in your home?

__

How many children live in your home?

__

How long have you lived in your home?

(1) ❑ Less than 1 year

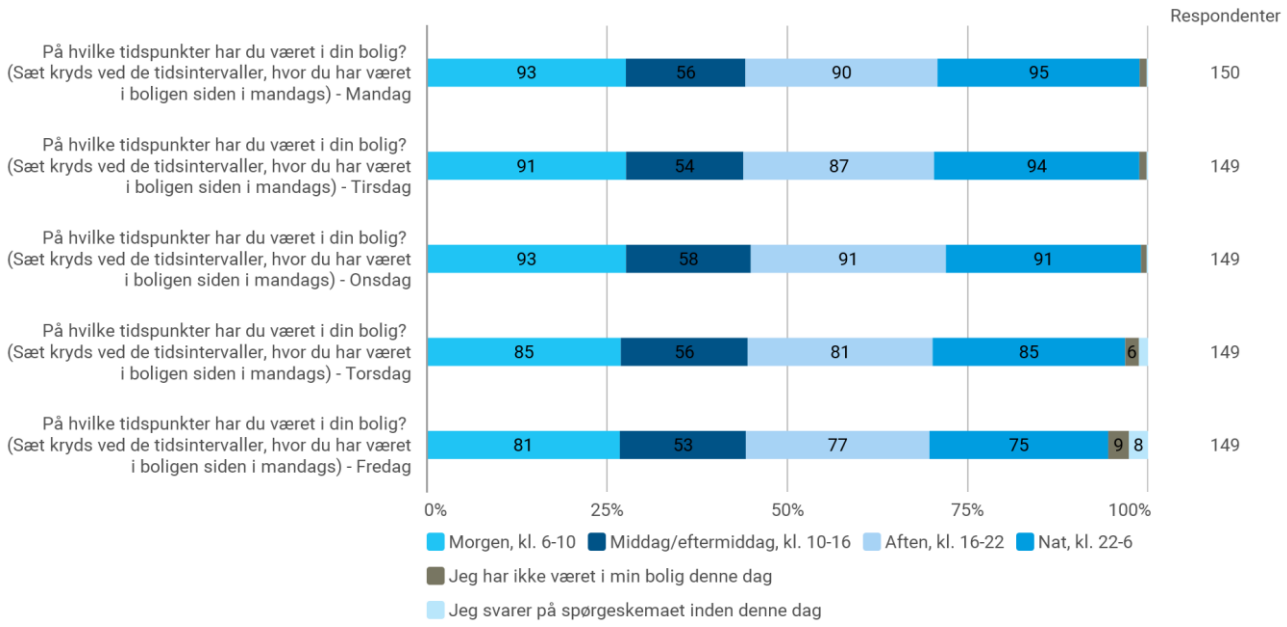
(3) ❑ 1 year or longer

Thank you very much for taking the time to answer the questionnaire.

You end your answer by pressing "Finish".

ANNEX 11: QUESTIONNAIRE RESULTS

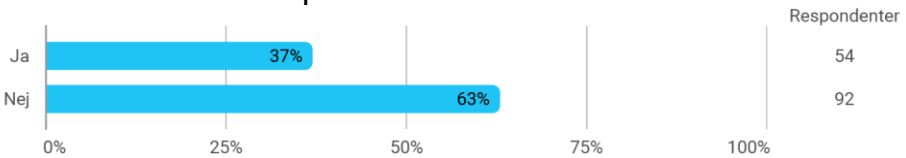
In annex 11 answers and comments to the questions from all participants, all weeks and all days are presented. To prevent translation issues the comments has not been translated, but the essence is extracted and included in the analysis.



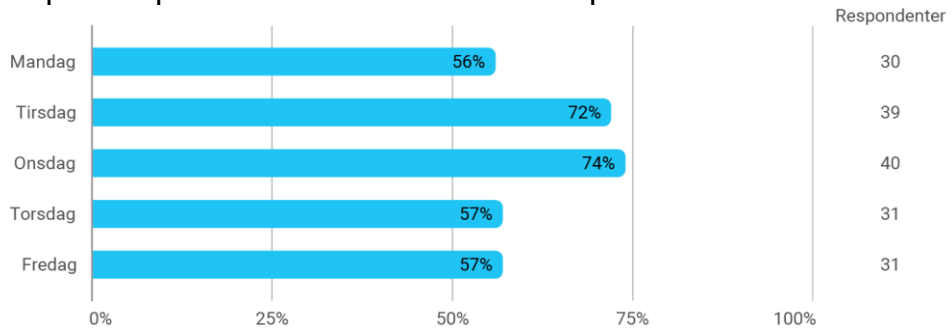
Uddyb eventuelt dit svar:

- Vi er naturligvis ikke hjemme hele tiden, men samlet er vi hjemme hele dagen
- Ferie i Tyskland onsdag-søndag.
- Ferie i Tyskland onsdag-søndag.
- jeg svarer lørdag
- I skal tænke på, at min mand arbejder hjemmefra, og ofte er den ene af os hjemme.
- Weekend hjemme hele weekenden
- Grundet corona-retningslinier var hele familien hjemme både torsdag og fredag
- Vi er alle fire hjemme 24/7 pga coronarestriktioner.
- Alle er hjemme 24/7 pga coronarestriktioner
- Jeg tror, vi er nødt til at gå ud af forsøget. Jeg troede, at jeg havde fået styr på radiatorerne, men det har jeg ikke. Jeg skal stadig køre radiatorerne for højt op for at få varme på, så bliver det for varmt, jeg skruer lidt ned igen og varmen forsvinder. Jeg aner ikke hvad det er hvad, men jeg går ikke ud fra at I tager al varme fra vores stue om eftermiddagen. Jeg aner ikke, hvad jeg skal svare jer.
- Vi har ikke været hjemme siden onsdag kl 16.
- Vi er i sommerhus

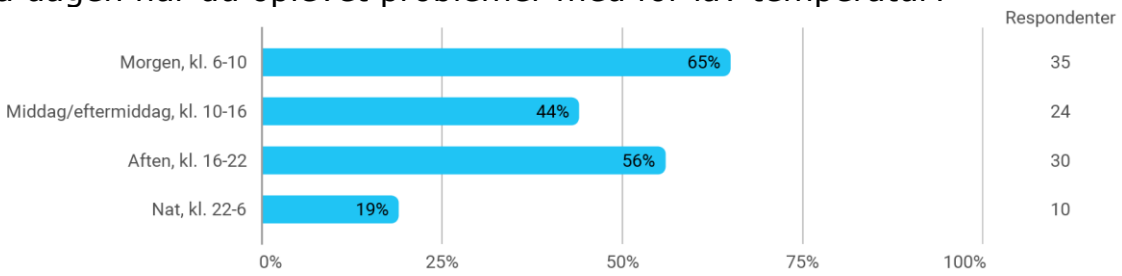
Har du oplevet problemer med for lav temperatur?



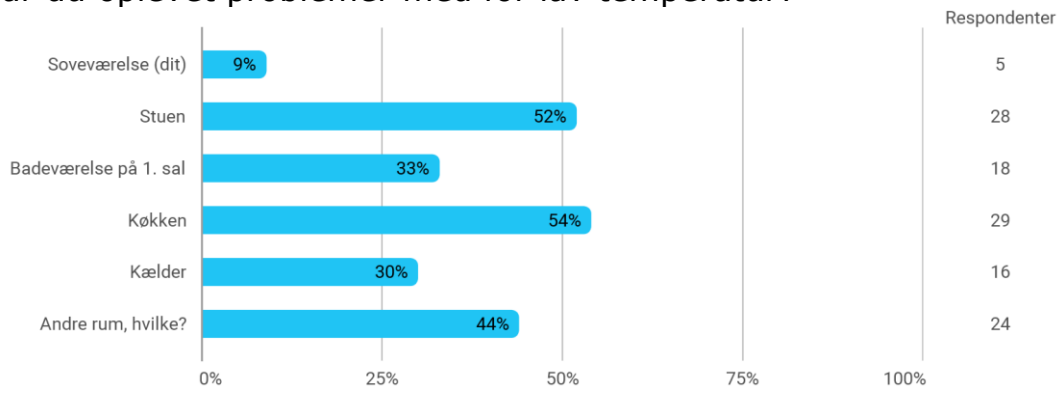
På hvilke dage har du oplevet problemer med for lav temperatur?



Hvornår på dagen har du oplevet problemer med for lav temperatur?



I hvilke rum har du oplevet problemer med for lav temperatur?



I hvilke rum har du oplevet problemer med for lav temperatur? - Andre rum, hvilke?

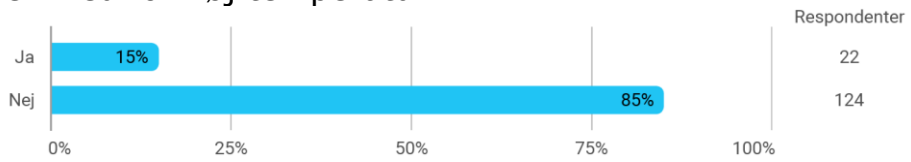
- Badeværelse stueetagen og det lille værelse på 1. sal
- Værelse på første sal
- værelse mod nord
- værelse ovenpå
- 1. sal generelt
- Værelset mod nord
- Lille værelse 1. Sal
- badeværelse i stuen
- værelse mod nord
- Toilet i stueetage
- Værelse mod nord, gæstetoilet.
- 1.sal stor værelse ved siden af soveværelse.
- værelse mod nord, gæstetoilet og entre
- Toilet
- Toilet
- Badeværelse, stuen
- Toilet
- Toilet
- Toilet
- Toilet
- Lille værelse, 1. sal
- lille toilet

- Toilet
- Toilet

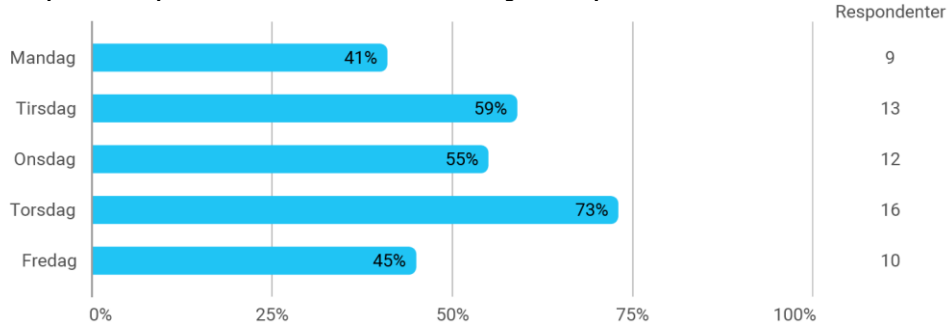
Uddyb gerne dine svar angående oplevede problemer med for lav temperatur:

- Der er for stor udsving på badeværelset.
- Radiatorerne er kolde, men det er ikke sommer. er man for længe i et værelse, begynder man at fryse meget
- Radiatoren i køkkenet følger ikke radiatoren i stuen, selv om det er samme rum,. Den er næsten altid kold
- Vi har sat temperaturen op til 20 grader i stuen, køkkenet og i kælderen. Det er stadig ret koldt i huset
- vores stue og køkken er ét rum. Torsdag var radiatoren i køkken kold hele dagen og aften, men radiatoren i stuen var lidt varm. Fredag var begge radiatorer kolde hele dagen. Der var meget koldt!
- Termostater stod på 16 grader. Vi fik skruet op.
- Der var koldt i køkkenet onsdag morgen kl 6.30. Min mand skruede straks op for radiatoren! :-)
- Det er vist termostaterne, der ikke fungerer. Jeg kontakter Lisbeth.
- Den skruer ned til 16 grader og det er derfor meget koldt om morgenen. Specielt frustrerende hvor der sover børn da de ligger ovenpå dynen, og dermed bliver forkølet.
- Generelt alt for koldt i køkken og stuer. Ofte slet ikke varme på radiatorerne - i køkken aldrig varme. I kælder stadig lav selvom den skrues op.
- Man har fundet ud af, at disse tre radiatorer ikke vil virke. Jeg ved ikke, hvad der skal gøres ved det
- Jeg har en radiator i det store kælderrum, som jeg af og til skruer helt op for fordi rummet kan blive fugtigt, så der er brug for meget varme fra den ene radiator, som oveni købet er i den ene ende af rummet. Men selvom jeg har skruet den op på 26 grader så er den stadig kun halvvarm. To-tre gange de sidste uger har den stået på 16 grader selvom jeg har sat den på 26... Hvordan kan det lade sig gøre? Det er som jeg også skrev sidst problematisk at termostaterne ikke virker som termostater men kun som tænd-sluk knapper. Vi leder efter en gennemsnitstemperatur, så huset er jævnt varmt. Men en radiator kan stå på 21 grader og være brændende varm, og en anden kan stå på samme, men være helt kold. Det frustrerende er desuden at man aldrig helt kan vide hvilke radiatorer der er hvad, hvornår. Vi kan f.eks. komme hjem til et koldt rum selv om radiatoren står på 21 grader og - samtidig! til et andet rum der er alt for varmt, selvom radiatoren står på 21 grader. Det er simpelthen alt for svært at styre og det kan virkelig ikke passe at det her er miljøvenligt, da vi hele tiden kører på enten 0 eller 100 og så at radiatorerne har deres eget liv så de kan opvarme et rum alt for meget selvom vi slet ikke skal bruge det.
- Temperaturen i stuen er på den ene radiator ved vinduet 16 grader - den anden er 20 grader både morgen og aften.
  Det er for koldt.
- Der virkede koldt torsdag aften, men ikke mere end en varm trøje kunne klare det.
- Termostaten stod på 16 grader om morgenen, og det var koldt. Der er også ofte for koldt på det store værelse på 1. Sal. Hvis der bliver skruet en halv grad op bliver det for varmt.
- Der var kold i stuen der var 21grader om aftenen
- Jeg kan ikke udfylde det
- temperaturen er faldet 1 grad
- Som sagt sidste gang, så er det nu muligt at få en mellemvarme, men det er stadig vanskeligt at gennemskue hvad radiatoren skal stå på for at holde en jævn varme

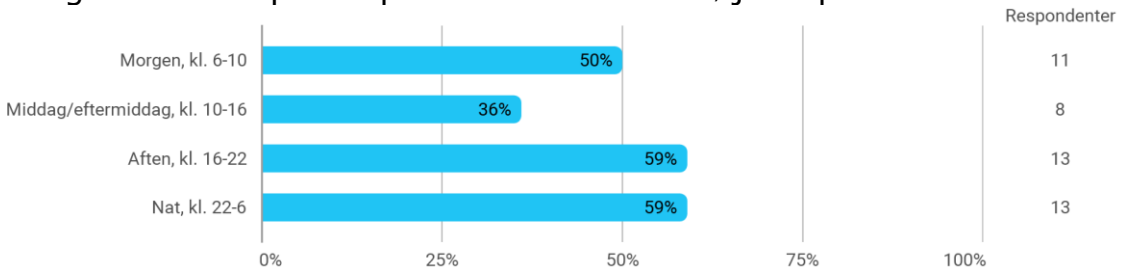
Har du oplevet problemer med for høj temperatur?



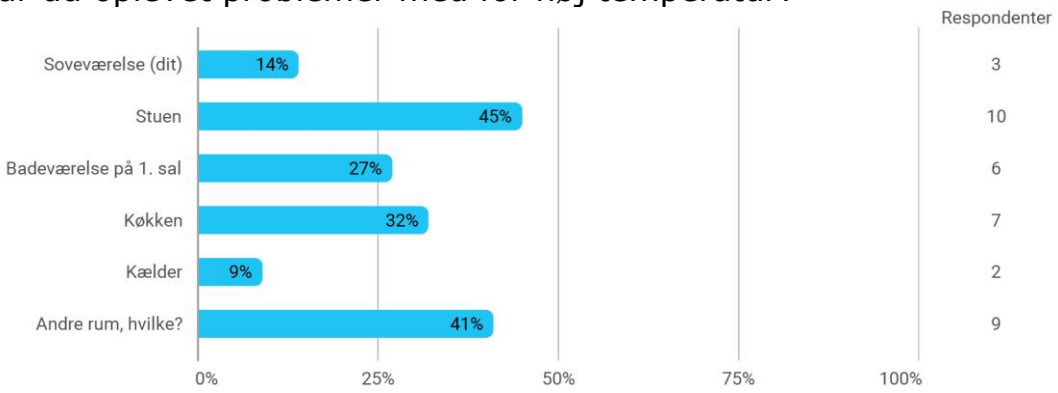
På hvilke dage har du oplevet problemer med for høj temperatur?



Hvornår på dagen har du oplevet problemer med for høj temperatur?



I hvilke rum har du oplevet problemer med for høj temperatur?



I hvilke rum har du oplevet problemer med for høj temperatur? - Andre rum, hvilke?

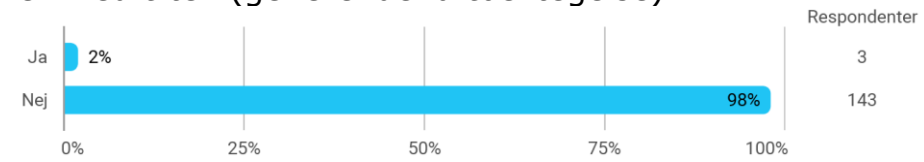
- Lille værelse på 1.sal
- værelse ovenpå
- Toilet stueetage
- Lille værelse 1.sal
- Lille værelse på 1.sal.
- 1. Sal lille værelse.
- Andet soveværelse, 1. sal
- Lille værelse 1. Sal
- Andet soveværelse, 1. sal

Uddyb gerne dine svar angående oplevede problemer med for høj temperatur:

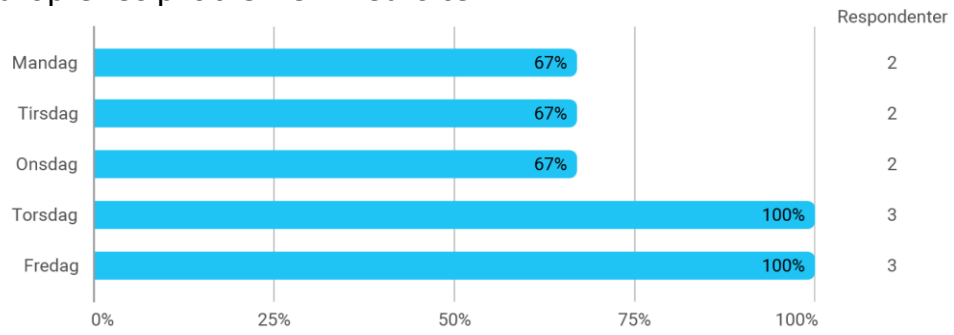
- For stor udsving mellem kold og varm
- Kun den ene radiator ved vinduet, selv om alle radiatorer i stue og køkken er indstillet ens
- Radiatoren kørte for fuld knald selvom der var varmt. Det virker som om den kører med alt eller intet.
- Når radiatorerne bliver aktiveret til at varme meget, varmer de alt for meget. De udtører træmøbler og trævindueskarme og blomster, og det suser i hele huset i radiatorene
- Jeg havde sat temperaturen til 21 g - så varmer radiatoren helt vildt. Har skruet ned til 20,5 g - så er der koldt.
- Onsdag kørte radiatorerne på fuld tryk hele dagen - alt for varmt
- Den kørte på fuld knald da jeg skulle i seng. Der virkede også til at være over 25 grader i rummet.
- Måske betinget af at vi skruede op for varmen onsdag morgen. Men køkkenet føltes for varmt
- Der var meget varmt torsdag morgen, men jeg forestiller mig at det skyldes at der blev skruet op onsdag morgen.
- Den kører på fuld knald selvom temp tydeligt er langt over indstillingen. Personlig vurdering vil være omkring 26 grader.
- Kan ikke huske hvilken dag. Den kører ofte i lang tid selvom det er meget varmt i rummet.
- Det er som jeg også skrev sidst problematisk at termostaterne ikke virker som termostater men kun som tænd-sluk knapper. Vi leder efter en gennemsnitstemperatur, så huset er jævnt varmt. Men en radiator kan stå på 21 grader og være brændende varm, og en anden kan stå på samme, men være helt kold. Det frustrerende er desuden at man aldrig helt kan vide hvilke radiatorer der er hvad, hvornår. Vi kan f.eks. komme hjem til et koldt rum selv om radiatoren står på 21 grader og - samtidig! til et andet rum der er alt for varmt, selvom radiatoren står på 21 grader. Det er simpelthen alt for svært at styre og det kan virkelig ikke passe at det her er miljøvenligt, da vi hele tiden kører på enten 0 eller 100 og så at radiatorerne har deres eget liv så de kan opvarme et rum alt for meget selvom vi slet ikke skal bruge det.
- radiatoren var meget varm, så jeg skruer lidt ned

- Selvom der er plusgrader udenfor, har vi oplevet at vores radiatorer i de to værelser på 1. sal var varme om natten -.
  Vi har kun oplevet det få gange tidligere. Men selv i frostnætter har der ikke været varme på om natten/morgenen ´. Og det er jo spild af varme, både fordi vi ikke ønsker varme om natten og fordi vi sover for åbne vinduer.
- Har en radiator i stuen som køre på fuldt blus - stadigvæk på trods af at den står på 16 grader.
  har først at tage batterierne ud og sætte dem ind igen. Den står stadigvæk på 16 grader og radiatoren køre på fuldt blus.
- Det var så varmt på værelse omkring kl 23. Det føles som Langt over 25 grader selvom termostaten står til 21,5. Både tirsdag og torsdag.
- Den ene af termostaterne i stuen er der noget galt med.Radiatoren køre på fuldt blus.
- Har stadigvæk en termostat/radiator som køre for fuldt blus i stuen.
- F.eks.: Køkkenradiatoren står på 22 grader - og det er ofte ok, men om morgenen er det for koldt - så skruer vi op på 24 grader, men så går den helt amok om aftenen og først på natten - og det er jo slet ikke nødvendigt at have brandvarme radiatorer kl. 2 om natten - den varme er stort set forsvundet om morgenen

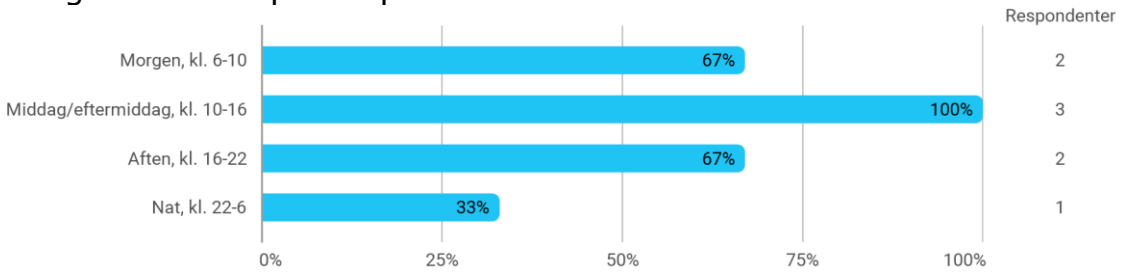
Har du oplevet problemer med træk (generende luftbevægelse)?



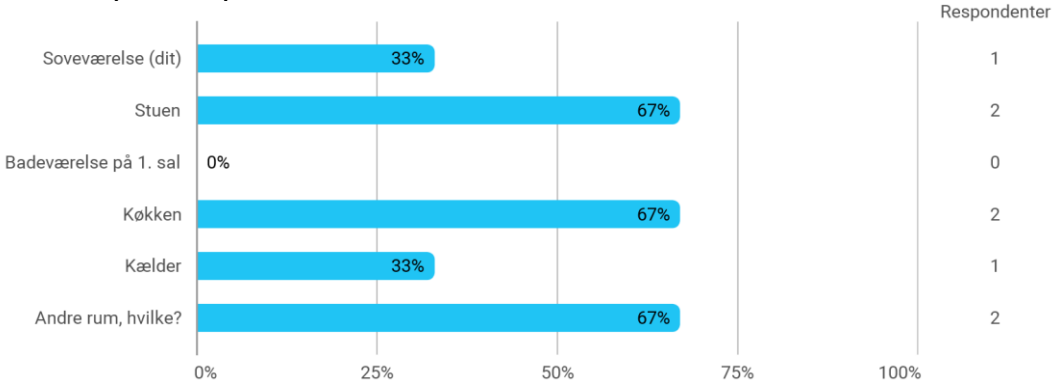
På hvilke dage har du oplevet problemer med træk?



Hvornår på dagen har du oplevet problemer med træk?



I hvilke rum har du oplevet problemer med træk?

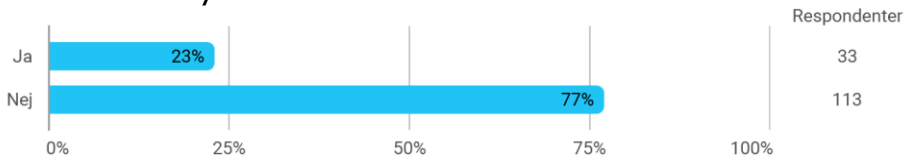


I hvilke rum har du oplevet problemer med træk? - Andre rum, hvilke?

- trappeopgang
- Trapperummet

Uddyb gerne dine svar angående oplevede problemer med træk:

Har du oplevet problemer med de nye termostater?

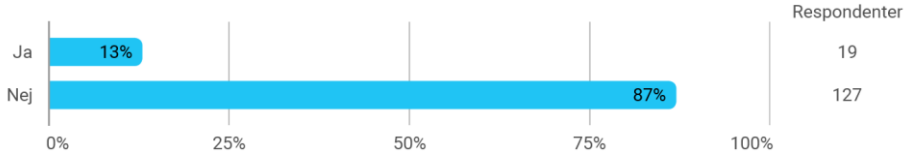


Hvilke problemer har du oplevet med termostaterne?
Beskriv problemerne (bl.a. hvornår og i hvilke rum de optrådte):

- Termostaterne på toiletter reagerrer for langsomt
- For stor ud svingmellem kold. Og varm
- Termostat i køkken følger ikke den anden radiator i samme rum. Den er kold, hvis jeg ikke skruer op for den. Jeg har taget batteriet ud to gange, men det hjælper ikke. Vi oplever stadig, at vi er nødt til at skrue termostaterne op til ca.23`før de virker, hvis vi vil have mere varme, og så varmer de alt for meget. De står og kører på fuld tryk og bliver alt for varme.
- Se tidligere svar
- Jeg synes at de er lidt ustabile. Temperaturen svinger selv om termostaten ikke bliver rørt.
- Hvis jeg fryser og lukker højere op for termostaten, bliver den hurtig for varm, og jeg må skrue ned igen. Det er svært at regulere den.
- Det suse4 generelt i rørene. Det var stoppet på et tidspunkt, men er begyndt periodisk igen. Det virker ikke som om termostaterne altid kan finde ud af at lukke en lille smule op for varmen.
- de radiatorer, som vi har bedt om at vi selv administrer kan ikke fungere under 23´, og på 23´står de og kører på fuld tryk. De fungerer overhovedet ikke som almindelige termostater
- DE VISER IKKE TEMPERATUREN, MEN ET ANDET TEGN, SOM IKKE ER TIL AT LÆSE.
- Har beskrevet tidligere
- Jeg kan være i tvivl om de virker
- Det er stadig et problem at de ofte ikke kører på en middeltemperatur, men er endten kolde elleralt for varme.
  De radiatorer vi selv styrer er stadig ikke mulige at få til at køre på under 23´, og derfor kører de også på fuld tryk
- jeg har været nødt til at fjerne batteri på næsten dem alle, for at få dem i gang igen. Det lykkedes ikke helt.
  Jeg synes, det er svært at regulere termostaterne til en passende temperatur.
- Jeg synes generelt ikke de er gode til at holde jævn varme. Det virker til at de kører med alt eller intet.
- toiletter termostater reagerer fof langsomt
- Badeværelset på første sal koldt om natten
- Fejlmelding på termonstaten i stuen.
  Det er måske fikset nu... måske.
- Hvis jeg skruer en halv grad op i toiletrum i stueetage, kører radiatoren på høj varme istedet for bare at blive en smule varmere
- Selv om jeg har fjernet et batteri og sat det indígena, virker det ikke på alle radiatorer. Se tdl svar.
- Som beskrevet tidligere.
- De fungerer ikke som termostater men som en tænd-sluk knap. Står den på 21 grader er radiatoren generelt kold, skruer vi op til 23 grader bliver den brændende varm.
- Der kommer ingen varme igennem - eller det er noget helt andet??
- Generelt, som sagt: at de ikke fungerer som termostater, men som tænd og sluk knapper for varmen. Det er også irriterende og upraktisk at hele termostaten drejer rundt, når man vil skifte temperatur, så man skal ned og have to hænder på.
- At de ikke fungerer som termostater, men kun som tænd-sluk-knapper
  Problemet er generelt. I alle rum.
  I de sidste uger har vi desuden oplevet at flere af termostaterne er blevet skruet ned på 16 uden at vi har rørt dem.
- Se tidligere svar med termostat i stuen.
- I alle rum - de fungerer ikke som termostater, men som tænd-sluk knapper - de virker kun i spændet mellem 22 og 24. På 21 er radiatoren som regel kold, nogle gange også på 22 - Når vi så skruer op på 23 eller 24 bliver den lynhurtigt brændende varm. Vi kan altså overhovedet ikke få mellemvarme.

- Den ene af termostaterne i stuen er der noget galt med. Radiatoren køre på fuldt blus
- I denne uge har jeg, for første gang i hele forløbet, oplevet lune radiatorer. Så der er nu en mellemting mellem kold og varm.
  Jeg har dog haft alle termostaterne til at stå på 23 eller 24 for at opnå denne mellemvarme.
  I lille værelse på 1. sal ville jeg skrue lidt op og skruede op til 25 uden særlig effekt. Skruede derpå til 26 og så blev radiatoren brændende varm på et øjeblik. Så der er stadig noget der ikke fungerer optimalt. I det store rum i kælderen har jeg forsøgt at holde en god varme af hensyn til mulig fugt og har været nødt til at skrue helt op på 30. Men netop den radiator kan jeg ikke få fuld skrue på. Og det vil jeg gerne kunne.
- Har en radiator i stuen som konstant køre for fuldt blus. Stadigvæk.
- Alle rum - jeg ved ikke om det egentlig er termostaterne eller om det er den fjernstyring der foregår, for det er ret uigennemskueligt hvorfor de reagerer som de gør

Har du oplevet problemer med radiatorerne?



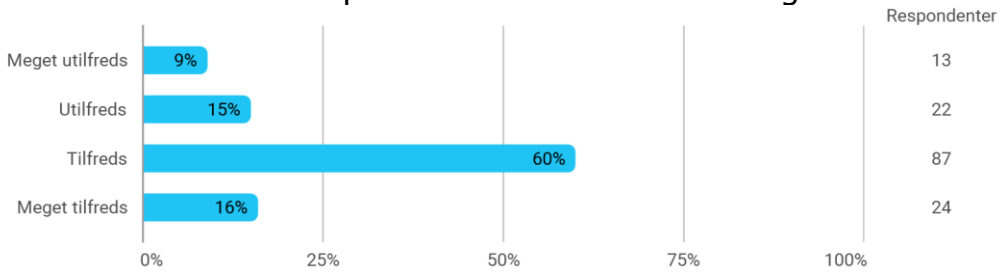
Hvilke problemer har du oplevet med radiatorerne?
Beskriv problemerne (bl.a. hvornår og i hvilke rum de optrådte):

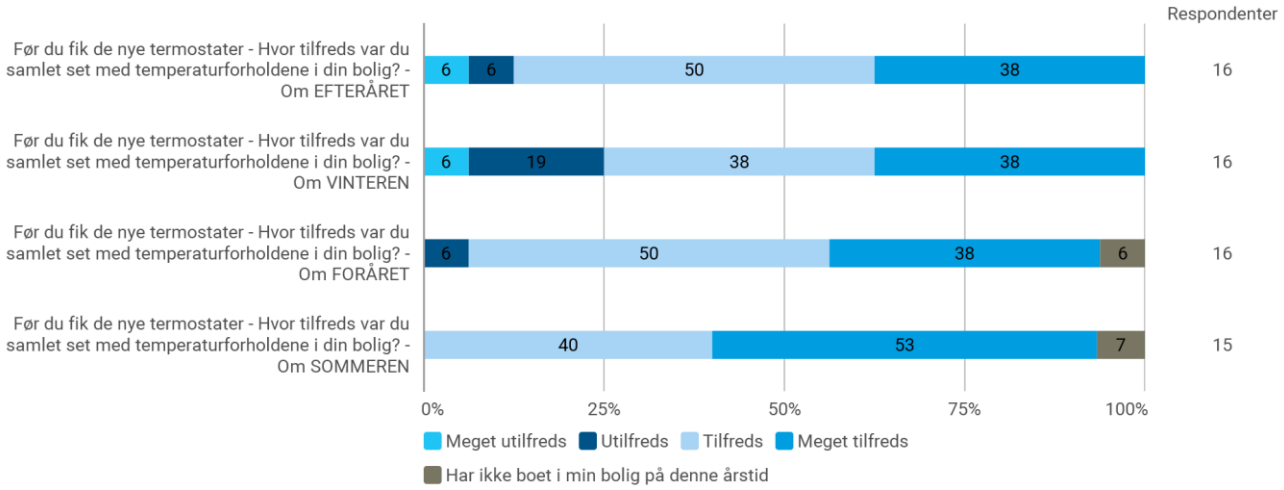
- Badeværelset meget varmt og meget koldt
- som tidligere beskrevet
- se tidligere svar
- De er slukket hele tiden
- Badeværelset er radiatoren kold eller,meget varmt
- som beskrevet i det forrige
- det er lidt tilfældigt om de er tændt eller slukket.
- FOR LAV VARME
- Toilet stueetage
- Når radiatorerne kører på fuld tryk larmer det i hele huset
- Koldt på badeværelse første sal varmen er ikke til at styre
- Den ene af radiatorerne under vinduet i stuen kører med varme, mens radiatoren under det andet vindue og radiatoren i køkkenet er kolde
- Se forrige svar
- hvis de ikke stilles ret højt (25-27 grader), forsvinder varmen fuldkommen.
- Se tidligere svar med radiator i stuen.
- Se foregående svar
- SE tidligere svar
- Den ene radiator i stuen laver bankelyde, når temperaturen sættes op
- Radiatoren under det høre vindue i stuen laver bankelyde - der er ikke rørt ved termostaterne forinden

Har du oplevet andre problemer med temperaturforholdene i din bolig?
Beskriv problemerne (bl.a. hvornår og i hvilke rum de optrådte):

- I mandags faldt temperaturen i en periode - og kom så igen.
- I mandags faldt temperaturen i en periode - og kom så igen.
- Det er generelt blevet koldere i huset. Blæsten og utætheder har muligvis noget af skylden. Det bliver ret koldt i hele huset når radiatoren i kælderen ikke varmer
- det har jeg beskrevet under termostaterne
- Der er ind imellem koldt og så er det for varmt, men også ok det meste af tiden
- nej
- vi har stadig problemer med indstilling af radiatorerne, se forrige svar.
- Se generel beskrivelse på næste side
- Det er stadig det samme, men jeg har fået bedre styr på det.
- Der er stadig for koldt i visse rum, men det er blevet bedre
- De beskrevne problemer er generelle ja, og gælder alle rum

Hvor tilfreds er du samlet set med temperaturforholdene i din bolig?





Uddyb gerne dit svar:

- Det kan jeg ikke huske, men nu er vi ved at være godt trætte af det
- Det plejede at være svært at varme huset op om vinteren og enkelte rum kunne føles kolde. Nu er der en meget mere jævn temperatur.
- TIL TIDER FOR KOLDT
- Vi har jo selv justeret efter behov.
- Vi bestemte selv temperaturen, og det var lettere at regulere

Er der andet, positivt eller negativt, som du ønsker at fremhæve eller blot gerne vil nævne, kan du skrive det her:

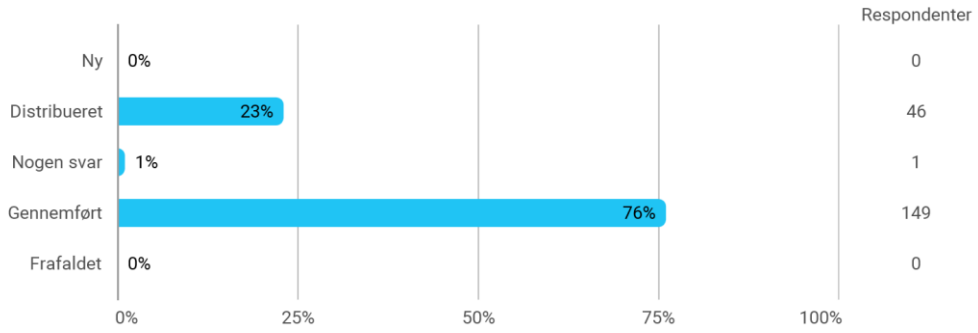
- Termostaterne er for store og vender forkert
- Hvis vi ikke ændrer på indstillingerne på termostaterne, ser det ud til at de ikke længere varmer så voldsomt som før, og det er godt.
- Jeg synes radiatorerne "snakker" en del, men det er ikke et problem.
- Hej.

  Min kone og jeg har været hjemme en stor del af tiden den sidste uge. Nogle gange kan det være lidt koldt på loftet, men der har vi jo også termostaterne stående lavt. Lige nu er det lidt koldt på loftet. Fredag eftermiddag kl. 17. Nogle gange skinner solen og varmer lejligheden op.Andre gange arbejde vi selv og mærker derfor ikke om temperaturen er lav. Derfor kan vi ikke besvare dit skema så præcist. Det er ikke noget vi går og tænker over. Denne besvarelse er også fra min kone Ingrid Noe-Nygaard. God weekend til jer. Hilsen Laurids Pedersen
- Hvis der skrues op for temperaturen på det ene værelse på 1. sal (min søns), larmer/suser det i radiatoren i mit soveværelse
- Det er svært at få tid til at udfylde skemaet inden weekenden
- Mig og min kone skriver dette skema sammen. Derfor kommer der ikke en beskrivelse fra hendes skema. Hendes navn er Ingrid Noe-Nygaard.
- Jeg er rigtig, rigtig træt af at fryse, når jeg skal i bad.
  Både min mand og jeg er blevet forkølet, fordi der så tit er koldt. Det nytter jo ikke noget at sætte temperaturen op, når der helt er slukket for varmen på flere radiatorer.
- Der er levet varmere på toilettet,har sat den op på23,5
- Vi er ved at være godt trætte af at termostaterne ikke virker på middeltemperatur (dem vi selv styrer)

Og vi er trætte af at fryse og svede og at have brændvarme radiatorer, som udtørrer karme pog møbler, der står tæt på radiatorerne

- Beklager min reaktion på manglende varme i badeværelset. Lisbeth har ringet til mig for at minde mig om, at jeg skulle genstarte termostaterne. Det er jeg i gang med.
  Undskyld det sene svar, jeg havde gæster hele week-enden.
- Det virkede som om radiatorene onsdag morgen selv skruede ned for varmen igen.
  Var henne og skrue de samme radiatore op på grader flere gange.... Det er dumt.
- Varmen i de forskellige rum er ikke altid ens. Vi undre os sommer tider over hvad det er der sker.
- Til tider ujævn varme i forskellige rum
- Der er kommet varme i kælderen. Det betyder meget for helhedsfornemmelsen i boligen. Bortset fra koldt køkken og værelse mod nord, har det været fint. Jeg er ligeglad med om der er varme på gæstetoilettet.
- Hvordan kan det være at weekenden ikke er med på listen så man kan besvare hvordan forholdene har været der?
- svinger en del - af og til for koldt og af og til for varmt
- Bortset fra, at jeg fryser, er alt ok
- Vi har oplevet for høj temperatur i nogle rum i visse tilfælde. Der har også været tidspunkter med for lav temperatur i visse rum. Jeg har ikke fået det noteret. Nogle gange er man også mere end frosenpind end andre gange.
- Der har været problemer med at ramme den rette temperatur ind imellem. Radiatorerne opfører sig mærkeligt en gang imellem.
- Jeg kan dårligt beskrive hvor meget vi glæder os til at få nogle termostater der virker, og til selv at få styring over vores varme. Alle radiatorerne har deres fuldstændigt eget liv - i hvert fald som vi oplever det. Nogle rum er alt for kolde, nogle alt for varme.
  Vi kan ingen logik finde, og derfor heller ikke skabe en struktur, som vi kan gå med. Vi er derfor tvunget til at skrue ned og op helt vilkårligt efter behov. Og så en meget mærkelig ting: hvordan kan det være at flere af termostaterne automatisk går ned på 16 - igen helt vilkårligt og uden genkendeligt mønster.
- Jeg tænker, at det vil være smart, hvis vi i de enkelte boliger kan tilgå en digital løsning, hvor vi kan indstille temperaturerne i for hver enkelt radiator i et planlægningsskema.
- Termostater skal pilles af så snart test perioden er overstået. De er virkelig irriterende. De kører ofte på fuld knald og det suser i rørene i hele huset.
- Der er meget varmt i stuen når solen skinner og radiatorerne køre ,sidst på eftermiddagen er radiatorerne kolde,starter først om aftenen.
- Jeg har jo skrevet det flere gange før, for ingenting har basalt set ændret sig. Jo: en mærkværdig ting er begyndt at ske de sidste uger. "Nogen" tillader sig at skrue flere af vores radiatorer ned på 16 med det resultat at i de rum, hvor vi har ønsket en rimelig morgentemperatur, der er det meget koldt istedet.
  I denne tid hvor vi jo opholder meget hjemme og indenfor, dels pga corona situationen, dels pga sygdom (dog ikke corona) er det frustrerende at vi kun kan vælge mellem kolde radiatorer og brandvarme.
  Temperaturerne i rummene skifter således også og vi risikerer at blive forkølede hvilket ikke ville være godt i vores nuværende situation.
  Så af mange mange grunde er den måde varmesystemet fungerer på nu - eller rettere: ikke fungerer på, problematisk for os - men det føles også klimamæssigt meget uhensigtsmæssigt at svinge mellem kulde og varme på den måde.
- Der har været problemer med for lidt varme ind i mellem. Hvor og Hvornår er dog lidt mere diffus
- Køligt ind imellem. Ikke huske hvor og hvornår.
- Jeg synes stadig, det er svært at få en fornemmelse af hvornår vi bestemmer og der er noget eksternt der bestemmer.
  Og generelt er der vel stadig et problem hos os, da den svage varme starter på 24 - skulle vel være lavere?
- Der har været skide koldt ind imellem. Det er bare ikke til at notere i skemaet, så skal man jo huske hvornår det var og i hvilke rum det var og det kan jeg ikke. Vi har jo nye termostater. De skulle jo give jævn varme, men det gør de ikke altid.
- Meget ujævn fordeling af varme i løbet af døgnet. Flere dage.
- Der er en chance for at termostaterne nu virker, men det virker som om basisindstillingen er for høj - nogle ganhge skal vi på 22 andre 23 eller 24 for at få varme i radiatorerne.
  Jeg synes ikke det virker at vores radiatorer bliver fjern-indstillet. Vi har slet ikke styr på hvordan vi kan regulere varmen i de forskellige rum i forhold til hvor meget og hvordan vi bruger rummene.
  Så vi ønsker at få fuld kontrol over alle radiatorerne nu - om termostaterne skal skiftes til den gamle type ved jeg ikke men vi kunne jo for en tid se om vi kan få dem til at fungere hvis vi selv kan styre dem helt og fuldt - også pga corona, der vanskeliggør montørarbejde i vores hjem...
  Mvh. Bjarne
- Jævnligt for koldt på forskellige tidspunkter
- Tit koldt på uforklarlige tidspunkter.

Samlet status



Spørgeskema udsendt til ialt 196 respondenter
149 har fuldført besvarelsen, svarende til en svarprocent på 149/196: **76%**

Responses per test week
1 16
2 17
3 14
4 15
5 14
6 14
7 16
8 13
9 15
10 15